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CSERIAC-RA-97-003A

Expanded Air Force Physical Fitness Battery: Muscle Strength, Muscle Endurance, and Flexibility Considered

Volume I, Final Report

Prepared for: OFFICE FOR PREVENTION AND HEALTH SERVICES ASSESSMENT
ARMSTRONG LABORATORY
BROOKS AIR FORCE BASE, TEXAS

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DISTRIBUTION STATEMENT A
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CSERIAC is a US Department of Defense Information Analysis Center, managed by the Defense Technical Information Center, Alexandria, VA, hosted by the Armstrong Laboratory, Human Engineering Division, Wright-Patterson Air Force Base, OH, and operated by the University of Dayton Research Institute.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	10/30/97	Review & Analysis: Final Report

4. TITLE AND SUBTITLE
Expanded Air Force Physical Fitness Battery: Muscle Strength, Muscle Endurance, and Flexibility Considered: Volume I, Final Report.

5. FUNDING NUMBERS
SPO900-94-D-0001

6. AUTHOR(S)
Barbara Palmer and Jennifer Soest

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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Commercial: (937) 255-4842 DSN: 785-4842

8. PERFORMING ORGANIZATION REPORT NUMBER
RA-97-003A

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office for Prevention and Health Services Assessment
Armstrong Laboratory
Brooks Air Force Base, Texas

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
This report contains three volumes. Volume I, this volume, is the final report on issues relevant to the Air Force's consideration of strength and flexibility as additions to the Air Force Fitness Program. Volume II contains pertinent non-copyrighted citations extracted from government databases, and Volume III contains pertinent copyrighted citations extracted from commercial databases. A Table of Contents for the three-volume set may be found in Volume I.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.	A

13. ABSTRACT *(Maximum 200 Words)*
The current Air Force fitness test is a submaximal cycle ergometry test which is used to estimate cardiovascular fitness. Interest in adding to this fitness requirement has arisen from several quarters. CSERIAC, the Crew System Ergonomics Information Analysis Center, produced this Review & Analysis that analyzes advantages and disadvantages to the Air Force of adding muscle strength, muscle endurance, and flexibility requirements to the Air Force fitness battery.

It was concluded that, of the benefits of strength training, improved deployment preparedness, safe and efficient everyday work performance, and safer aerobic and team activity are most important to the Air Force. Secondly, although the evidence is not absolutely conclusive, the preservation of bone mass through strength training is also important to the Air Force, especially as more women enter, and retire from, the Air Force.

The benefits of flexibility training are less clear. While flexibility training seems to be a universal prescription in fitness and health texts, the scientific data do not universally support the purported benefits of flexibility training, especially in the area of sports injury protection. However, on the basis of recommendations of other fitness programs and the opinions of subject-matter experts, and because better flexibility may reduce lower back pain and prevent injury from falls, it is suggested that the Air Force add flexibility training to its program.

14. SUBJECT TERMS
Physical Fitness; Health; Air Force; Military Medicine; Strength (General); Strength (Physiology); Flexibility

15. NUMBER OF PAGES
75

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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VOLUME I
FINAL REPORT
TABLE OF CONTENTS

VOLUME II TABLE OF CONTENTS
TABLE OF CONTENTS
NON-COPYRIGHTED CITATIONS

VOLUME III
TABLE OF CONTENTS
COPYRIGHTED CITATIONS

VOLUME I
FINAL REPORT
LIST OF TABLES

FOREWORD

This report documents a *Review & Analysis* of an Expanded Air Force Physical Fitness Battery. The task was performed by the Crew System Ergonomics Information Analysis Center (CSERIAC) for the Air Force's Office for Prevention and Health Services Assessment of the Armstrong Laboratory. It was conducted under Department of Defense Contract Number SPO900-97-D-0001.

The CSERIAC Director during this period was Mr. Donald A. Dreesbach. The primary human factors analyst and author was Barbara Palmer, who was assisted by Jennifer Soest. Ms. Soest compiled most of the tables for this *Review & Analysis*. CSERIAC also acknowledges the assistance of University of Dayton Technical Information Services for their support and cooperation in the compilation of literature search material. Finally, we appreciate the project suggestions and editorial comments from Dr. Aaron W. Schopper.

EXECUTIVE SUMMARY

The current Air Force fitness test is a submaximal cycle ergometry test which is used to estimate cardiovascular fitness. Interest in adding to this fitness requirement has arisen from several quarters. Following a fall 1996 Fitness Summit III, the Air Force Fitness Science & Research Consultants of the Office for Prevention and Health Services Assessment tasked CSERIAC, the Crew System Ergonomics Information Analysis Center, with production of a document that would analyze advantages and disadvantages to the Air Force of adding muscle strength, muscle endurance, and flexibility requirements to the Air Force fitness battery. Muscle strength and muscle endurance are related on an absolute basis. Both concepts will be assumed with the use of the word "strength" for purposes of this *Review & Analysis*; muscle fitness is also a term used to encompass these concepts. While the fitness program is certainly focused on the active duty Air Force, health issues presented here will have implications for the retired population as well. Suggestions that bone mass and flexibility are important for elderly citizens are made with the assumption that the levels of these variables at the time the person separates from the Air Force influence their levels from that time forward.

Information from scientific and technical reports, as well as books, the World Wide Web, and more popular periodicals was read and analyzed, and these conclusions were reached:

1. The Air Force needs to be a fit force so that

   - personnel will be able to perform well under deployment or emergency conditions
   - everyday jobs can be undertaken safely and efficiently
   - costs due to absenteeism and medical problems will be minimized

2. Compared to (a) definitions of fitness as expressed in major fitness texts and other literature; (b) fitness programs recommended by national fitness and health organizations; and (c) fitness programs of other military and government organizations, the Air Force Fitness Program appears to be relatively narrow in its focus. Most definitions, recommendations, and other fitness programs incorporate strength training, and some include flexibility as well.

3. To varying degrees, the following are seen as potential benefits to the Air Force of promoting strength training and flexibility training:

   - Troops whose strength training mirrors the kinds of actions that might be required during deployment will be better able to function, physically and mentally, in emergency conditions.

   - Strength training helps in the safe and efficient performance of everyday tasks.

   - Strength training programs will produce increased strength, increased muscular fitness, increased lean mass, decreased body fat, and increased bone mass.

   - Strength training, probably largely through its effect on muscle mass, can increase rates of resting basal metabolism, which is a benefit in controlling body weight.

   - Strength training can help maintain bone density and prevent osteoporosis.

- Strength training produces strong muscles, ligaments, and tendons, which serve as protection against injury during deployment, everyday work, and sports activities.

- Some strength training regimens produce a modest aerobic benefit.

- Strength training may alleviate some common musculoskeletal complaints which require time off from work and costly medical treatment.

- Full-range-of-motion strength training may promote flexibility.

- Strength training may have a positive effect on cardiovascular health.

- Strength training improves self-image and mood.

- Flexibility training may lower the incidence of back pain.

- Flexibility training may promote safer physical activity, although data are inconclusive.

- Flexibility training may reduce injury due to falls, a consideration for the retired Air Force population.

4. It was concluded that, of the benefits of strength training, deployment preparedness, safe and efficient everyday work performance, and safer aerobic and team activity resulting from strength training are most important to the Air Force. Secondly, although the evidence is not absolutely conclusive, the preservation of bone mass through strength training is also important to the Air Force, especially as more women enter, and retire from, the Air Force.

5. The benefits of flexibility training are less clear. While flexibility training seems to be a universal prescription in fitness and health texts, the scientific data do not universally support the purported benefits of flexibility training, especially in the area of sports injury protection. However, on the basis of recommendations of other fitness programs and the opinions of subject-matter experts, and because better flexibility may reduce lower back pain and prevent injury from falls, it is suggested that the Air Force add flexibility training to its program.

6. It is recommended that the Air Force Surgeon General be an advocate for duty-time fitness activities, so that training, not testing, is emphasized. The Air Force, of all the US military Services, does not have an official policy that mandates duty time for physical fitness, although many commanders do encourage these hours. A change in this policy would be a great motivator for personnel to engage in fitness activities. It would indicate how seriously the Air Force regards physical fitness.

7. Although this *Review & Analysis* presents suggestions for measures of strength and flexibility, a genuinely defensible test battery should be based on an analysis of everyday work and/or military tasks. Tasks required of all personnel during Air Force deployment could be documented and could form the basis for a physical fitness test battery, or tasks performed in different career fields could form the basis of selective (by unit or command) test requirements.

The Canadian Armed Forces has established minimal physical fitness standards based on seven common military tasks which all personnel might be required to perform in an emergency situation.

8. This *Review & Analysis* also presents potential drawbacks to these recommendations. The cost of making such a widespread change in the Air Force fitness program is discussed, and it is emphasized that progressing from a *decision* to include new components in the fitness program to the *creation* of an actual program, which is scientifically based and detailed enough to be consistently administered, will be complicated and time-consuming. While this *Review & Analysis* suggests a program of implementation and specific test batteries, these ideas must be considered to be preliminary. Subsequent to a decision about a specific test battery, the development of standards will have to be undertaken, a topic which is fraught with scientific, social, and legal implications.

1.0 INTRODUCTION

The current Air Force fitness test is a submaximal cycle ergometry test which is used to estimate cardiovascular fitness. Interest in adding to this fitness requirement has arisen from several quarters. While *Air Force Instruction 40-501* emphasizes cardiorespiratory fitness, *Department of Defense Directive 1308.2* requires that individual Service members possess, in addition to cardiorespiratory fitness, muscular strength, muscle endurance, and whole-body flexibility so that they may successfully perform in accordance with their Service-specific mission and military specialty. The United States Surgeon General's first report on fitness, *Physical Activity and Health: A Report of the Surgeon General* (US Department of Health and Human Services), published in July 1996, states that moderate physical activity could offer a substantial health benefit to most Americans, and could lower their risks of suffering from heart disease, diabetes, colon cancer, and high blood pressure. Activities which promote muscle strength and endurance, and flexibility, are specifically recommended. A more recent initiative, Operation Be Fit (Air Force News Service, 1997), puts into action the Department of Defense's stated commitment to military physical fitness. The Department of Defense's March 1997 initiative confirms the Department of Defense's leadership position regarding physical fitness activities and programs. The Department of Defense will encourage all military members to participate in the programs being set up by Operation Be Fit, which will include fitness, sports, and recreation activities. Standards and actions are expected to be issued in the fall of 1997.

These programs and instructions have had an impact on the Air Force Fitness Program Office. The Air Force Fitness Program Office implements, sustains, and supports the Air Force Fitness Program (AFFP), and represents the AFFP to all Air Force entities. The Air Force Surgeon General's office is responsible for AFFP policy and procedures. The Air Force Fitness Program rests on two pillars of the Air Force Surgeon General's health initiatives, readiness and building healthy communities. At a fall 1996 Fitness Summit III (Air Force Fitness Program Office, 1996), the Office for Prevention and Health Services Assessment reported that the fitness program, per the Air Force Surgeon General, would be developing more comprehensive requirements, including strength and flexibility. An August 1996 memorandum from the Associate Director of the Air Force Medical Operations Agency of the Office of the Surgeon General emphasized a charge to the Air Force Fitness Program that strength and flexibility as well as other issues be examined by a Science Board.

Following this fall 1996 meeting, the Air Force Fitness Science & Research Consultants tasked CSERIAC, the Crew System Ergonomics Information Analysis Center, with production of a document that would analyze the benefits and costs to the Air Force, if any, of adding muscle strength, muscle endurance, and flexibility requirements to the Air Force fitness standard. (The use of the word "strength" in the remainder of this *Review & Analysis* will include the concepts of both muscle strength and muscle endurance; see Section 4.1 for rationale.) Benefits were expected to be addressed in the context of military readiness and health issues. Costs to be considered included the steps required to progress from a decision about expanding the fitness program to the creation and documentation of a reliable and valid set of measures which could effectively assess the fitness of a large-scale adult population. A large subset of issues to be dealt with in the generation of such a program deals with the determination of standards, the pass-fail levels for each test measure.

1.1 OBJECTIVES

The purpose of this *Review & Analysis* is to examine the specific, individual benefits of strength and flexibility training and to evaluate their implications and importance to the Air Force, as well as to consider the costs and disadvantages associated with making a change to the Air Force Fitness Program. Leading up to analysis of strength and flexibility benefits, this document analyzes these issues:

- Why must the Air Force be a fit force?
- What tasks should Air Force personnel be fit enough to perform?
- What does it mean to be physically fit?
- How does the Air Force Fitness Program compare to other fitness programs?

Against the backdrop created by the answers to the above issues, this *Review & Analysis* then documents the benefits of strength and flexibility and summarizes their usefulness to the Air Force. A plan for implementing recommended changes is then detailed. Issues posed include:

- How can personnel be motivated to train?
- Is a duty-time fitness policy needed?
- What steps are involved in the creation of a new fitness program?
- What metrics or standards (establishing pass/fail criteria) are defensible?

2.0 APPROACH

2.1 INFORMATION SOURCES

Information for this *Review & Analysis* was gathered from several sources. The bulk of information was derived from published literature, including books, technical reports, and journals from the fields of fitness, sports medicine, physiology, medicine, and others. Relevant literature was identified subsequent to a comprehensive computerized search of the literature. Literature searches were performed on several databases, including:

Defense Technical Information Center (DTIC) Technical Reports (TR)
Advisory Group for Aerospace Research & Development AGARD
Dissertation Abstracts On-line
National Aviation & Space Administration - Remote Control (NASA Recon)
SPORTDiscus

Relevant and recent literature and researchers were identified and this information was used to access other sources. From over a thousand citations (see Volumes 2 and 3), 150 journal articles, technical reports, and book chapters were obtained, reviewed, and analyzed for this report. In addition to databases of literature, additional information was obtained through World Wide Web newsgroups, subject matter experts, and electronic documents.

2.2 ORGANIZATION OF THE *REVIEW & ANALYSIS*

The first section of this *Review & Analysis* examines the various reasons that the Air Force needs to be a fit force. Then, a current definition of what it means to be fit is established. Against this backdrop, the current Air Force Fitness Program is evaluated.

Specific benefits of strength and flexibility training are examined. The results of all previous sections are synthesized, and recommendations are made. Drawbacks are discussed, and a specific implementation plan is presented.

3.0 THE AIR FORCE FITNESS PROGRAM: COMPARISONS

The purpose of this section is to compare the Air Force's fitness needs against current definitions of fitness. After a discussion of the reasons why the Air Force must be a fit force, a backdrop is created from several types of input about what it means to be fit. These definitions come not just from the literature and subject matter experts, but also from programs of other military and government organizations and from fitness programs prescribed by national health and fitness associations. Then the current Air Force Fitness Program is evaluated, so that it can be determined if the Air Force is fit enough.

3.1 WHY THE AIR FORCE MUST BE A FIT FORCE

Why does the Air Force need a fit force? What is the motivation behind the Air Force's fitness policy? There are many reasons that the Air Force must be a fit force. These include:

- Troops must be ready in case of deployment.
- Personnel must be able to perform their daily work efficiently and safely with minimal absenteeism.
- Health costs will be lower if the work force has fewer illnesses and injuries and a lower mortality rate.

Addressing the three main thrusts of emergency preparedness, everyday job performance, and health, Assistant Secretary of Defense for Force Management Policy Fred Pang expresses the importance of fitness this way:

> Maintaining the peace through military training and preparedness—and fighting a war if necessary—calls for men and women who are extremely fit. What we spend in fitness, sports, and recreation programs that lead to physical fitness is an investment. It's the human side of force modernization. When military community participation in regular physical activity increases, we free up health care dollars that can be used for other critical needs. We also get the significant benefit of having a total work force that does the job better than ever before. (Pang cited in Air Force News Service, 1997, p. 22)

3.1.1 Deployment Readiness

USAF Lt Col Destadio (1991) states that the current emphasis on physical fitness in the Air Force is a function of the realization that combat readiness increases as physical conditioning levels increase. The relationship between physical fitness and military performance is clear. Personnel who are aerobically fit and have good muscle strength and endurance are better able to perform tasks under emergency conditions. Experience and research have validated the claim that physical strength and endurance increase with physical training. Soldiers who are physically ready can overcome fatigue and minor illnesses better than those who are less physically ready (Hertling, 1987).

There is a trend among the services to emphasize duty-specific fitness programs, that is, programs whose fitness goals are based on tasks to be performed, especially during wartime. Work by Vickers (1996) and others model physical task performance as a basis for job design, fitness requirements, and simulation and modeling. An exemplary physical fitness program enacted by the 363 Civil Engineering Squadron at Shaw Air Force Base, SC, demonstrates this link between a task-specific fitness program and wartime performance. Called the Combat PT Program, the fitness plan was based on the squadron's wartime mission, to perform Rapid Runway Repair (repair to bomb-damaged runways with AM-2 aluminum matting) and to provide basic facilities for incoming troops. Mandatory, duty-time physical fitness was conducted three days a week from 1987-1990. Aerobic fitness was emphasized, along with upper body strength and endurance. Proof of their success was evident in the lowered completion times for the AM-2 mat; stamina and endurance improved as well, as documented in the Hq TAC 1990 Operational Readiness Inspection of the 363 Tactical Fighter Wing. During the inspection, despite the fact that CES personnel wore chemical warfare gear, not one CES individual had to stop working, or had difficulty breathing. Furthermore, during Desert Shield, the unit constructed a tent city, which housed 3000 people, in temperatures higher than 100 degrees F, in six days. Other, less-fit individuals had to stay sheltered during the day, while CES members provided food, shelter and latrine facilities (Destadio, 1991).

Also addressing the specific, minimal tasks that troops should be prepared to perform is the quote of US Marine Corps 29th Commandant General Alfred Gray (Associated Press Dispatch, 1987):

> There are those who pride themselves on the number of push-ups, sit-ups, and chin-ups they can perform, but no one has stressed how they can carry a wounded Marine the length of the parade ground without killing him. That is what we should know and be able to do. If some want to run in their silk shorts and Adidas that's fine with me, but the Corps is going to return to Physical Readiness Training vs. physical fitness. (p. 3)

An Army viewpoint also emphasizes the need for fitness that will allow the completion of tasks during combat:

> The Army must get tough. While we should still look askance at the overweight NCO or the officer who can't climb a flight of stairs without becoming winded, our emphasis should be readjusted to evaluate the soldier's ability to perform his assigned mission on the next battlefield. If he fatigues carrying the light pack a few miles in training, he will certainly become a casualty when marching toward the guns weighted with his combat load. If she hasn't been exposed to strenuous muscular fatigue in physical training, she certainly won't be able to emplace a signal cable. . . numerous times. If the NCO can't

> swim and he's assigned to a unit where river crossings are likely, prepare for a leadership casualty. . . . If we, as an army, don't subject ourselves to more physical and emotional stress than two minutes worth of pushups and situps and a 20-minute jog around the post, our best technology and doctrine may be wasted. (Hertling, 1987, p. 41-42)

Does this emphasis hold for the Air Force? Is there a rationale for the Air Force to hold itself to a different standard relative to other forces? Does the fact that the majority of Army functions require ongoing physical labor and the majority of Air Force jobs do not mean that the members of the Air Force need not be as physically fit? In the case of readiness, it is true that the Air Force differs from other Services in the kinds of tasks that are required during deployment. Some would argue that, for the Air Force, the warfighters are pilots, not ground troops or infantry. Do Air Force personnel need to be very physically fit for deployment, given their probable tasks in such a situation?

At first glance it might appear that the distinctions among different wartime tasks allow the Air Force to be held to a different fitness standard, since the majority of Air Force troops would not be performing the kinds of tasks that infantry battalions do. Despite the emphasis by some on the pilot-warfighter, many occupations within the Air Force, performed on an ongoing basis as well as those that might be needed during deployment, *do* require physical labor. Some units will be fit enough for deployment due to their everyday military jobs, such as civil engineering or maintenance units who lift and load on a daily basis. But consider medical personnel who, when deployed, must carry over a hundred pounds of medical equipment, as well as personal gear, as they get on and off the aircraft. When on the ground, medical personnel must then be prepared to erect tents, and later to transport patients on gurneys. Medical personnel, whose daily tasks may not be physically demanding, may be faced with a sudden demand to perform physical labor. They won't be prepared for physical labor from their daily work tasks. Only fitness training outside of the work arena can prepare them sufficiently for deployment. It could be argued that the mission of the US Air Force is to maintain a level of fitness year-round that will allow all personnel to perform any possible deployment task without fatigue under harsh environmental conditions when time and other stressors will provide additional taxation of resources. If there is to be just one fitness standard for the US Air Force, should that standard represent the degree of fitness required to do the most difficult task to be found during deployment, under the most rigorous environmental and stress pressures imaginable? This quote from General Fogleman refocuses the mission of the Air Force and allows us to consider, unapologetically, an increased standard for Air Force fitness:

> We are not a social actions agency. We are not an employment agency. We exist to fight and win wars. That's our core expertise. That's what allows us to be called military professionals. (Fogleman, 1997)

This view is supported by Destadio (1991), who makes the point that:

> (while). . . the physical demands of Air Force specialties differ, each and every member must possess the physical ability to endure, to withstand stress, and to carry on when an unfit person

> cannot. Physically fit individuals are also more resistant to illness and disease and quicker to recover from injury than are unfit individuals. (p. 27)

Another country's set of minimum physical fitness standards may help give us rationale for the establishment of a combat-based Air Force fitness program. The Canadian Armed Forces compiled a list of military tasks that might be required of any military person during emergency action. All military personnel, regardless of their peacetime assignment, no matter what their wartime task might be, no matter how unlikely it is that the person in question will ever be in an emergency situation, ought to be able to perform these minimal emergency situation tasks. As part of a project to determine physical fitness levels which would be the minimum needed to complete specific, common, military tasks, the Canadian Forces created the following list of tasks which all Canadian Forces should be able to perform in times of emergency. From Stevenson et al. (1988), the tasks are to:

1. Operate one's personal weapon
2. Function effectively in nuclear/biochemical warfare clothing
3. Perform first aid and casualty evacuation
4. Perform fire-fighting duties
5. Execute survival search and rescue techniques
6. Perform general security duties (including rush and shoot, low and high crawl)
7. Perform Task No. 6 in nuclear/biochemical warfare clothing

In addition to the element of better physical preparedness during deployment is the importance of *cognitive* task performance during deployment. Decision making in the heat of battle must be supported by as many resources as possible. Cognitive performance as well as physical performance may be enhanced under emergency conditions if personnel are physically fit. An Army report (Pleban, Thomas, & Thompson, 1985) found that more physically fit soldiers, as assessed on a battery consisting of chin-ups, push-ups, sit-ups, two-mile run time, and pulse rate by the Harvard Step Test, performed better on a cognitive test battery and had lower fatigue ratings during a two-and-a-half day Ranger-type sustained operations simulation. Hegge (1981) also reports that the rate of performance decline during sustained combat operations may be slowed by increased physical fitness. While much of Hegge's work focuses on muscular effort, Pleban et al. assert, "there is some reason to believe that they (the relationships between resource utilization and fitness) also influence cognitive work capacity as well." (p. 1)

Telford (1996) of the Royal Australian Air Force speaks to the many aspects of deployment which could be positively affected by physical fitness:

> It is well accepted that being 'physically fit' improves your quality as well as quantity of life. As a member of the RAAF, there is an added dimension to your personal fitness--it has the potential to protect the quality of lives of all Australians. Put it this way. Who would I trust to defend my country in a fighter aircraft, or to service that aircraft under trying conditions or to plan strategies or combat late at night after a long stressful day,

> or to treat or nurse the injured and ill in remote locations? The sedentary, overweight individual with no interest in their physical fitness or the active, lean individual who has taken a keen interest in his or her physical condition?
>
> There may be those who try to rationalise their lack of fitness by claiming that their role in the RAAF is to use their 'brain' not their 'brawn'. This belief, even if their lack of physical contribution could be covered, is still tenuous when one considers that any member who is deployed is going to be required to think clearly under various types of physical stress. The basic biochemistry associated with physical stress indicates that those whose physical work capacity is low, are likely to plan less effectively and think less cogently at any given level of physical stress, be it environmental or otherwise. (p. 1)

3.1.2 Everyday Work Performance and Fitness

Besides deployment readiness, the everyday work arena benefits from a fit workforce. Workers who are fit are more productive, are happier, are absent less often, and are injured less on-the-job. The Air Force will gain productivity and lowered health and absenteeism costs with a more fit staff. Healthy and fit workers are more productive. They suffer less from fatigue and make fewer errors (Shephard, 1992). Fit workers are absent less often, file fewer insurance claims and injure themselves less frequently. A NASA and US Public Health Service survey (Durbeck et al., 1973) of more than 200 Federal employees who participated in a worksite exercise program revealed that workers who exercised felt that, as a result, they could work harder mentally and physically, they enjoyed their work more, and found their normal work routine less boring.

Adequate strength to do a specific Air Force job is determined through the Air Force's Strength Aptitude Test (Ayoub, Jiang, Smith, Selan, & McDaniel, 1987). This test is an incremental lift test which qualifies enlistees for jobs demanding heavy physical work. The concern, however, in this *Review & Analysis*, is to establish in a more broad sense how general physical fitness allows work to be done more safely and efficiently. Adequate muscle strength lets us work more efficiently and therefore more productively, since our energy is being preserved. Wayne Westcott, Ph.D., a strength training consultant to the National Academy of Sports Medicine, and the American Council on Exercise, emphasizes that a person who is strong uses less effort to walk or push a pedal. The more energy a person saves, the greater endurance that person will have (Westcott in Eller, 1996).

Workers who are fit are less likely to have on-the-job injuries. An extensive review of the role of physical training in preventing occupational injuries can be found in a 1992 *Ergonomics* article entitled, *Physical Training: A Tool of Increasing Work Tolerance Limits of Employees Engaged in Manual Handling Tasks* (Genaidy, Karwowski, Guo, Hidalgo, and Garbutt, 1992). The article emphasizes a lack of physical fitness as a contributing factor to musculoskeletal injuries resulting from manual material handling in particular.

A 1992 U.S. Department of Health and Human Services survey included, as benefits of a physically fit workforce, improved employee morale, reduced health insurance costs, reduced absenteeism, increased output and productivity, reduced on-the-job accidents, and fewer

workers' compensation claims. Other fitness benefits in the workplace are documented by Canadian Life, whose absenteeism rate dropped 50% by employees who were "high adherents" in a fitness effort. At Prudential, disability days were reduced over 20% for employees who participated in a fitness program. Tenneco saw a trend for fewer sick hours for exercisers vs non-exercisers (cited in Nieman, 1995).

3.1.3 Medical Costs and Health Benefits

Estimates are made about cost to the general economy due to lifestyle-related diseases, but it is more difficult to estimate costs to the Air Force of an unfit work force. These same studies mentioned above showed that health costs were lower for groups of employees who exercised more than other groups. A Canadian Life company study showed that medical care costs were decreased for a group who exercised compared to workers who did not. At Prudential, disability days were reduced over 20% for employees who participated in a fitness program, and the more fit workers had a 46% lower rate of major medical costs. Tenneco saw 48% lower medical costs for an exercise group compared to non-exercisers (cited in Nieman, 1995).

The beneficial effects of exercise on health and wellness has been clearly documented in recent decades. In a 1986 article, Paffenbarger, Hyde, Wing, and Hsieh reported that people who exercise live longer than those who do not, and that those people who get a lot of exercise live longer than those who exercise less. Simply put, exercise increases longevity and decreases mortality rates. Exercise lowers the risk of fatal disease and thereby increases the lifespan. Disorders associated with a lack of physical activity include heart disease, hypertension, diabetes, osteoporosis, cancer, stroke, backache, and obesity. Wier (1992), at a NASA Occupational Health meeting, reports that exercise has been documented to reduce coronary heart disease, and also states:

> The value of exercise for preventing hypertension, stroke, diabetes, and osteoporosis and for rehabilitating the victims is also known. Recent research has also implicated physical activity in reducing the incidence of various forms of cancer. Workforce studies show that physical activity on the job reduces by half the incidence of colon cancer, and an impressive longitudinal study on 5300 women showed that a vigorous activity habit established early in life cut the risk of breast cancer by one-half and reproductive system cancer by two-thirds. The activity habit also lowers the risk of disability from chronic backache, which is the leading factor in industrial absenteeism. Also, exercise is the key to achieving and maintaining a healthy body weight. (p. 125)

Nieman (1995) gives us these descriptions of major sources of illness and death in the United States and elsewhere, which he and others believe are preventable or modifiable through lifestyle changes.

Cardiovascular Disease
Cardiovascular disease is the leading killer of people in the United States and in many other developed countries. Cardiovascular disease is a term that covers more than 20 different illnesses of the heart and vessels, including arteriosclerosis and atherosclerosis, which is the

underlying factor in 85% of heart disease deaths. Twenty percent of all heart attack deaths occur before the age of 65, making this factor relevant for Air Force fitness planners.

Hypertension

Hypertension should also be considered in Air Force fitness plan development due to its correlation to cardiovascular disease. High blood pressure has been identified as an influential contributor in the development of cardiovascular complications and mortality (U. S. Department of Health and Human Services, 1996). The risk of developing high blood pressure increases with age and is also dependent on several lifestyle measures including weight, and sodium and alcohol intake. Despite declining rates of hypertension in the US, 25% of Americans are still classified as hypertensive according to the Department of Health and Human Services standards (1996).

Diabetes

Upwards of 169,000 deaths annually are attributed to diabetes, making it the seventh leading cause of mortality in the US (U. S. Department of Health and Human Services, 1996). Diabetes mellitus is a group of metabolic disorders, most prominently displayed by elevated glucose levels. Some degree of glucose intolerance is exhibited in 11% (17 million) of the US population aged 20-74. Additionally, it is estimated that only-half of the diabetics are aware of their condition.

Osteoporosis

Osteoporosis is a disorder characterized by decreased bone mass and deterioration of bone tissue, resulting in bone fragility and increased susceptibility to fracture. This disease primarily affects older persons, and is more prevalent for women than men. In sum, osteoporosis afflicts 25 million Americans, and yearly accounts for an estimated 1.5 million fractures in persons over the age of 45.

Cancer

Cancer is the second leading cause of death in the US, accounting for 25% of all deaths (U. S. Department of Health and Human Services, 1996). Cancer can occur in any part of the body; it is a disease characterized by uncontrolled growth and spread of abnormal cells supported by various environmental and host factors. It is predicted that one-third of Americans now living will eventually have cancer.

Stroke

Strokes are a form of cardiovascular disease ranking as the third leading cause of death in the US (U. S. Department of Health and Human Services, 1996). Strokes are either ischemic or hemorrhagic in variety. The primary risk factors for strokes include high blood pressure, gender, family history, cigarette smoking, obesity, and race.

Back Pain

Low back pain ranks as the second most common ailment in the US and the third highest cause of time lost from work. Overall, it is estimated that back pain total costs range from $16-50 billion per year. Not all back pain is self-limiting; up to 5% of back pain sufferers develop a chronic condition, and at least a third have recurrent episodes. Most incidences of back pain occur between the ages of 25 and 60 and result from unusual stresses on the muscles and ligaments in the back.

Obesity
Obesity is a condition of excess body fat currently afflicting 58 million US adults aged 20-74. In addition, one-third of the American population is classified as obese, and 65% of the population is considered overweight. Several international comparisons have also revealed that Americans are among the heaviest people in the world. Obesity is a major health problem as it contributes to development of diabetes, heart disease, high blood pressure, osteoarthritis, cancer, and other diseases (U. S. Department of Health and Human Services, 1996).

All of these illnesses and conditions are considered to be modifiable to some extent by lifestyle factors, including physical activity. As people are living longer, it will behoove the Air Force to make sure that people are living as healthily as they can, in order to keep medical costs for a retired Air Force population as low as possible.

3.2 PHYSICAL FITNESS – DEFINITION AND DISTINCTIONS

This section defines what it means to be physically fit. Against this backdrop, it can be determined whether or not the current AFFP standards are engendering a work force that is fit enough for deployment, fit enough to do daily work safely and efficiently, and healthy enough to minimize days off work and medical costs. Does the AFFP mirror the definitions of physical fitness as determined by fitness literature of today?

3.2.1 Definitions of Fitness

Section 3.1 covered some of the benefits of general fitness. The focus now is to examine what it means to be physically fit. What state of fitness allows us to accrue health benefits and to be ready for deployment or to react in an emergency? What are the current national fitness programs? This section presents several definitions of fitness.

The Joint Department of Defense Committee on Fitness (Assistant Secretary of Defense, 1985) defines fitness as:

> The ability of service members to meet the physical demands of their jobs for an extended period of time and to have the additional ability of meeting physical emergencies, such as those imposed during combat or other stressful situations. The components of fitness generally are considered to be cardiorespiratory fitness (heart and lungs), muscular fitness (muscle strength and endurance), flexibility, body composition (fat vs muscle) and weight management. (p. 1)

Echoing the emphasis of the Air Force Fitness Program's dual pillars of readiness and health, the *Second International Consensus Symposium on Physical Activity, Fitness, and Health* (Bouchard, Shephard, Stephens, 1993) states that:

> Fitness is operationalized in present day Western societies with a focus on two goals: performance and health. Performance-related fitness refers to those components of fitness that are necessary for optimal work or sport performance. Health-related fitness refers to those components of fitness that are

> affected favorably or unfavorably by habitual physical activity and relate to health status. It has been defined as a state characterized by (a) an ability to perform daily activities with vigor, and (b) demonstration of traits and capacities that are associated with a low risk of premature development of hypokinetic diseases and conditions. Important components of health-related fitness include body mass for height, body composition, subcutaneous fat distribution, abdominal visceral fat, bone density, strength and endurance of the abdominal and dorso-lumbar musculature, heart and lung function, blood pressure, maximal aerobic power and capacity, glucose and insulin metabolism, blood lipid and lipoprotein profile, and the ratio of lipid to carbohydrate oxidized in a variety of situations. A favorable profile for these various factors presents a clear advantage in terms of health outcomes as assessed by morbidity and mortality statistics. (p. 15)

Nieman (1995) defines fitness as:

> the dynamic state of energy and vitality that enables one to carry out daily tasks, to engage in active leisure-time pursuits, and to meet unforeseen emergencies without undue fatigue. In addition, physically fit individuals have a decreased risk of hypokinetic diseases, are better able to function at their peak intellectual capacity while experiencing a sense of 'joie de vivre.' (p. 30)

Fitness has been defined as "the ability to perform muscular work satisfactorily" by the World Health Organization. The Centers for Disease Control and Prevention's board of experts defined fitness as a "set of attributes that people have or achieve that relates to the ability to perform physical activity." The American College of Sports Medicine states that "fitness is the ability to perform moderate to vigorous levels of physical activity without undue fatigue and the capability of maintaining such ability throughout life." The President's Council on Physical Fitness defines physical fitness as the "ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies." (cited in Nieman, 1995, p.31)

3.2.2 Components of Health-Related Fitness

Fitness encompasses two large components—performance fitness, which is that related to athletic performance, and health-related fitness, which is the focus of this *Review & Analysis*. Performance fitness includes the characteristics of agility, balance, coordination, speed, power, and reaction time, while health-related fitness is said to include cardiorespiratory endurance, body composition, musculoskeletal flexibility, muscle strength, and muscle endurance.

Cardiorespiratory Fitness

Cardiorespiratory fitness represents the body's capacity to perform tasks requiring large muscle groups for an extended period of time. Cardiorespiratory fitness depends on the ability of the circulatory and respiratory systems as they react to whole-body exercise, such as running,

cycling, or swimming. To many fitness professionals, cardiorespiratory fitness is the most important of the health-related fitness components. Cardiorespiratory fitness is most often measured by oxygen uptake during maximal, graded exercise, typically on a bicycle ergometer or treadmill. Less expensive test methods include field tests, stair climbing tests, and submaximal bicycle tests.

Body Composition
Body composition categories are fat vs lean body tissue, which includes muscle, bone, and water. Body mass is divided into fat mass and lean body tissue, or fat free mass. The preferred index of body composition is percent body fat, the percent of total mass represented by fat mass.

Muscular Strength
Muscular strength is the maximal one-effort force that can be exerted against resistance. Lifting a heavy weight one or two times, or exerting maximal grip with a hand dynamometer are examples of measures of muscular strength. The stronger the person, the greater the amount of force that can be generated.

Muscular Endurance
Muscular endurance is the muscle's ability to apply a submaximal force repeatedly, or to sustain a contraction over time. Exercises that increase and measure muscular endurance are sit-ups, push-ups, chin-ups, or lifting weights between 10 and 15 times.

Flexibility
Flexibility is the capacity of joints to move through a full range of movement. Flexibility is specific to each joint, and it is determined by muscles, ligaments, and tendons. Although there are inherent limitations, stretching exercises improve flexibility.

3.2.3 Balanced Fitness

How fit does an individual have to be to garner the health benefits expressed above? An individual must be how fit to be ready militarily? Is it enough to be cardiovascularly fit? There is evidence that the 70s and 80s were the era of aerobic fitness, but the 90s are seeing a new emphasis on strength training and balanced fitness (Nieman, 1995). Nieman states:

> The focus in the 1990s is to utilize a comprehensive physical fitness approach. During the boom years of the aerobic movement in the 1970s and the 1980s, cardiorespiratory conditioning was often the only type of exercise for many, leaving out exercises for flexibility and muscular strength and endurance. This was the reverse of what happened in the 1950s and the 1960s when muscular strength was preeminent, to the detriment of exercises for the heart and lungs. The comprehensive approach that is now emerging gives attention to both cardiorespiratory and musculoskeletal fitness. (p. 204)

In his 1995 book, *Fitness and Sports Medicine*, Nieman states that to develop total physical fitness for health, the five components which follow must be included in an exercise program. He stresses cardiovascular endurance, body composition, and musculoskeletal fitness, which is comprised of flexibility, muscular strength, and muscular endurance. Again and again the

literature reviewed for this *Review & Analysis* emphasizes the same elements included in DoDD 1308 as necessary for readiness and general health and well-being: cardiorespiratory endurance, muscular strength, muscle endurance, whole-body flexibility, and body composition.

3.2.3.1 Balanced Fitness Programs of National Stature

Health and fitness in America have received national attention since the 1970s. Many national mandates have been enacted since that decade, with increasing emphasis on how changes in lifestyle can promote health and longevity. Table 1, *Physical Activity Recommendations by National Fitness and Health Groups,* summarizes several sets of recommendations from national health and fitness organizations, and illustrates how strength training has come to be included in activities promoted by these groups. (Sources of information are included in the table.) For example, the American College of Sports Medicine added specific strength training guidance as late as 1990. The American Heart Association recommended endurance training alone in 1975 and added strength training in 1992. The majority of programs now recommend strength training in addition to endurance training, and flexibility training is also recommended in about a third of the programs. Highlighted here are excerpts from the American College of Sports Medicine Pronouncements and the US Department of Health and Human Services' Healthy People 2000 recommendations. Items in bold are added by the author to emphasize muscle strength recommendations.

3.2.3.1.1 American College of Sports Medicine Pronouncements The American College of Sports Medicine (ACSM) is an organization dedicated to generating and disseminating knowledge concerning the motivation, responses, adaptations and health aspects of persons engaged in sports and exercise. In response to the increasing number of persons involved in physical activity and the lack of guidelines for exercise prescription, the ACSM released their 1990 *Official Position Stand on The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness in Healthy Adults* (American College of Sports Medicine, 1990). Included in this report are recommendations regarding the quality and quantity of training for developing and maintaining cardiorespiratory fitness, body composition, and muscular strength and endurance in the healthy adult. The ACSM recommendations are these:

1. Frequency of training:
   3-5 days per week
2. Intensity of training:
   60-90% of maximum heart rate, or 50-85% of maximum oxygen uptake or maximum heart rate reserve
3. Duration of training:
   20-60 minutes of continuous aerobic activity. Duration is dependent on the intensity of the activity.
4. Mode of activity:
   Any activity that uses large muscles, can be maintained continuously, and is rhythmical and aerobic in nature.
5. **Resistance training:**
   Strength training of a moderate intensity, sufficient to develop and maintain fat-free weight. One set of 8-12 repetitions of eight to ten exercises that condition the major muscle groups at least 2 days per week.

Table 1. Physical Activity Recommendations by National Fitness and Health Groups (1965-1996)

Source	Objective	Type/Mode	Intensity[1]	Endurance Frequency	Duration	Resistance Training[2]
President's Council on Physical Fitness (1965)	Physical fitness	General fitness	Five levels	5 x week	≈ 30 minutes	Selected Calisthenics
American Heart Association Recommendations (1972)	Coronary heart disease prevention	Endurance	70-85% MHR	3-7 x week	15-20 minutes	Not addressed
Young Men's Christian Association (1973)	General health and fitness	Endurance, strength, flexibility	80% VO_2 max	3 x week	40-45 minutes	Not specified
American College of Sports Medicine Guidelines (1975)	Cardiorespiratory fitness	Endurance, strength, flexibility	60-90% VO_2 max; 60-90% HRR	3 x week	20-30 minutes	Not specified
American Heart Association Recommendations (1975)	Secondary prevention in patients with heart disease	Endurance	70-85% MHR	3-4 x week	20-60 minutes	Not addressed
American College of Sports Medicine Position Statement (1978)	Cardiorespiratory fitness and body composition	Endurance	50-85% VO_2 max; 50-85% HRR; 60-90% MHR	3-5 x week	15-60 minutes	Not addressed
US Dept Health, Education, and Welfare -- Healthy People (1979)	Disease prevention / health promotion	Endurance	Moderate / hard	3 x week	15-30 minutes	Not addressed
American College of Sports Medicine Guidelines (1980)	Cardiorespiratory fitness	Endurance, strength, flexibility	50-85% VO_2 max / HRR; 60-90% MHR	3-5 x week	15-60 minutes	Not specified
American College of Sports Medicine Guidelines (1986)	Cardiorespiratory fitness	Endurance, strength, flexibility	50-85% VO_2 max / HRR; 60-90% MHR	3-5 x week	15-60 minutes	Not specified
US Dept of Health and Human Services -- Surgeon General's Report on Nutrition and Health (1988)	Weight control	Endurance	Not specified	≥3 x week	≥20 minutes	Not addressed
US Preventative Services Task Force (1989)	Primary prevention in clinical practice	Not specified, implied endurance	At least moderate	Not specified	Not specified	Not addressed
American College of Sports Medicine Position Stand (1990)	Cardiorespiratory and muscular fitness	Endurance, strength	50-85% VO_2 max; 50-85% HRR; 60-90% MHR	3-5 x week	20-60 minutes	1 set, 8-12 repetitions 8-10 exercises 2 days x week
American College of Sports Medicine Guidelines (1991)	Cardiorespiratory fitness	Endurance, strength, flexibility	40-85% VO_2 max; 55-90% MHR; RPE = 12-16	3-5 x week	15-60 minutes	Not specified
American Association for Cardiovascular and Pulmonary Rehabilitation (1991)	Cardiac rehabilitation	Endurance, strength	Exercise following ACSM (1986) and AHA (1993)	3-5 x week	15-60 minutes	1-3 sets, 12-15 repetitions major muscle groups 2-3 days x week
US Dept of Health and Human Services -- Healthy People 2000 (1991)	Disease prevention / health promotion	Endurance, strength, flexibility	Light / moderate / vigorous	3-5 x week	20-30 minutes	Not specified
American Heart Association Position Statement (1992)	Cardiovascular disease prevention and rehabilitation	Endurance	> 50% VO_2 max	3-4 x week	30-60 minutes	Not addressed
American Heart Association Standards (1992 and 1995)	Coronary heart disease prevention and rehabilitation	Endurance, strength	50-60% VO_2 max; 50-60% HR reserve	≥3 x week	≥30 minutes	1 set, 10-15 repetitions 8-10 exercises, 2-3 days x week
American Association for Cardiovascular and Pulmonary Rehabilitation (1993)	Pulmonary rehabilitation	Endurance	60% HR reserve	3 x week	20-30 minutes	Not addressed
American College of Sports Medicine Position Statement (1993)	Prevention and treatment of hypertension	Endurance, strength	40-70% VO_2 max	3-5 x week	20-60 minutes	Not specified
American Heart Association Position Statement (1993)	Cardiovascular disease prevention and rehabilitation	Moderate intensity integrated into daily routine	Not specified	Not specified	Not specified	Not addressed
American College of Sports Medicine Position Stand (1994)	Secondary prevention in patients with coronary heart disease	Endurance, strength	40-85% VO_2 max; 40-85% HRR; 55-90% MHR	3 x week, nonconsecutive days	20-40 minutes	Not specified
American Heart Association Position Statement (1994)	Cardiac rehabilitation	Endurance and strength training of moderate intensity following other	Not specified	Not specified	Not specified	Not specified
American Association for Cardiovascular and Pulmonary Rehabilitation (1995)	Cardiac rehabilitation	Endurance, strength	> 50% VO_2 max; RPE 12-14	3-5 x week	30-45 minutes	1 set, 10-15 repetitions, major muscle groups 2-3 days x week
American College of Sports Medicine Guidelines (1995)	Cardiorespiratory and muscular fitness	Endurance, strength	40-85% VO_2 max / HRR; RPE 12-16	3-5 x week	12-15 minutes initially: 20-30 minutes for conditioning and maintaining	1 set, 8-12 repetitions 8-10 exercises 2 days x week
American College of Sports Medicine Position Stand (1995)	Prevention of osteoporosis	Strength, flexibility, coordination, cardiorespiratory fitness	Not specified	Not specified	Not specified	Not specified
Agency for Health Care Policy and Research (1995)	Cardiac rehabilitation	Endurance, strength	70-85% MHR	3 x week	20-40 minutes	Not specified
Centers for Disease Control and Prevention / American College of Sports Medicine (1995)	Health promotion	Endurance	Moderate / hard	All or most days	≥30 minutes per day in bouts of at least 8-10 minutes	Not specified
US Dept of Health and Human Services / USDA Guidelines (1995)	Health promotion / disease prevention, weight maintenance	Endurance	Moderate	All or most days	≥30 minutes per day	Not addressed
National Heart, Lung, and Blood Institute Consensus Conference (1996)	Cardiovascular disease prevention for adults and children and cardaic	Endurance	Moderate / hard	All or most days	≥30 minutes per day	Not addressed
US Preventative Services Task Force (1996)	Primary prevention in clinical practice	Endurance, strength, flexibility	Moderate	Most days	30 minutes	Not specified

Numerical Notes:
[1]Key to Intensity Abbreviations:
HRR = Heart Rate Reserve; MHR = Maximal Heart Rate; RPE = Rating of Perceived Exertion; VO2 max = Maximal Oxygen Uptake
[2]Resistance Training Explanations:
Not addressed = not included in recommendations; Not specified = recommended but not

Adapted from:
U. S. Department of Health and Human Services. (1996). *Physical activity and health: A report of the surgeon general.* Atlanta, GA: U. S. Department of Health and Human Services.

3.2.3.1.2 US Department of Health and Human Services *Healthy People 2000* is a statement of national objectives prepared by the US Department of Health and Human Services with the overall goal of improving American health. The report was produced because America's deadliest and costliest diseases are to some extent preventable. The goals of *Healthy People 2000* thus serve to promote healthy habits to prevent disease and lower health care costs on a national level (Wier, 1992). The three overarching goals for the year 2000 are to:

- Increase the span of healthy life for Americans
- Reduce health disparities among Americans
- Provide access to preventative services for all Americans

These objectives are further divided into 22 priority areas, with physical activity and fitness ranked as the top priority for health promotion. Some objectives listed for physical activity and fitness include:

- reducing coronary heart disease deaths
- reducing the proportion of overweight persons
- increasing physical activity
- light to moderate physical activity for at least 30 minutes a day
- vigorous physical activity for cardiorespiratory fitness 3 or more days per week for 20 or more minutes
- **exercises to promote muscular strength, muscular endurance, and flexibility**
- increasing the number of worksite programs
- increasing community accessibility and availability to fitness facilities
- increasing the primary care provider's role in fitness counseling

Specific fitness goals are:

- to increase to 30% the proportion of people aged 6 and older who engage regularly in light to moderate physical activity
- to increase to 20% the proportion of people 18 and older and to 75% the proportion of people 6 though 17 who exercise vigorously on a regular basis
- to reduce to no more than 15% the proportion of people 6 and older who engage in no leisure-time physical activity
- **to increase to at least 40% the proportion of people 6 and older who regularly perform physical activities that promote muscle strength, endurance, and flexibility**

3.3 THE AIR FORCE'S FITNESS PROGRAM

The reasons that the Air Force needs to be fit have been established: to be ready for deployment, to do everyday jobs efficiently and safely, and to minimize health risks. Section 3.2 presents some current definitions of what it means to be fit. Fitness experts and national programs appear to be unanimously in favor of a balanced approach to physical fitness. That is, a balanced approach takes into account body composition, aerobic conditioning, muscle strength, muscle

endurance, and flexibility, as well as nutrition and lifestyle variables. The purpose of this section is to define and discuss the Air Force Fitness Program to see how it compares with today's trend toward balanced fitness.

3.3.1 Directives, Instructions, and Programs Governing the Air Force's Physical Fitness Program

3.3.1.1 DoD 1308

Department of Defense Directive 1308.1, *DoD Physical Fitness and Body Fat Program* (Assistant Secretary of Defense, 1985), applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, and the Unified Combatant Commands. This policy states:

> It is DoD policy that physical fitness is essential to combat readiness and is an important part of the general health and well-being for Armed Forces personnel. Individual Service members must possess the cardio-respiratory endurance, muscular strength and endurance, and whole-body flexibility to successfully perform in accordance with their Service-specific mission, and military specialty. Those qualities, as well as balance, agility, and explosive power, together with levels of body composition, form the basis of the DoD Physical Fitness and Body Fat Program. (p.1)

Fitness is defined by DoDD 1308.2 as:

> The ability of service members to meet the physical demands of their jobs for an extended period of time and to have the additional ability of meeting physical emergencies, such as those imposed during combat or other stressful situations.

3.3.1.2 Air Force Instruction 40-501

Air Force Instruction 40-501 (Medical Command, Department of the Air Force, 1996) outlines the Air Force Fitness Program, and states that cardiovascular (aerobic) fitness is the single best indicator of total physical fitness. Components of the Air Force Fitness Program .are indicated as:

> 1.2.1 Achievement and maintenance of an active aerobic fitness lifestyle; this is the individual Air Force member's responsibility.
> 1.2.2 Assessment of the level of aerobic fitness by submaximal cycle ergometry; this is the responsibility of each member and unit commander. (Section 1.2)

Aerobic fitness improvement is the responsibility of the entire fitness team—member, unit commander, services personnel, medical personnel, and installation commander. The Air Force

is currently mandated to use submaximal cycle ergometry to estimate aerobic fitness, which is considered a representative measure of total physical fitness. Section 1.3.1 states that:

> Aerobic fitness assessments are used to measure compliance with a year-round physical conditioning program. Fitness standards are used to ensure a minimum level of aerobic fitness is maintained. Fitness assessments provide an excellent measure of total force aerobic fitness.

3.3.1.3 Air Force Fitness Program Office

The Air Force Fitness Program Office was established in June 1995, by the Office for Prevention and Health Services Assessment. The Fitness Program Office implements, sustains, and supports the Air Force Fitness Program (AFFP) for all Air Force entities. The Air Force Surgeon General's office is responsible for AFFP policy and procedures.

3.3.1.4 Operation Be Fit

The Department of Defense, in March 1997, mandated *Operation Be Fit*, an initiative to improve the physical fitness of the entire military community. The mandate confirms the Department of Defense's leadership regarding physical fitness activities and programs (Air Force News Service, 1997). The Department of Defense will encourage all military members to participate in the programs being set up by *Operation Be Fit*, which will include fitness, sports, and recreation activities. Standards and actions are expected to be issued in the fall of 1997.

3.3.2 Historical Description of Air Force Fitness Programs

The first Air Force publication regarding physical fitness was published in 1947. Although no standard program was documented, and no specific level of fitness was required, AFR 50-5 stated that the Air Force's fitness program should:

> A) Develop and maintain a high level of physical fitness in the individual so that he can perform more efficiently his assigned duties,
> B) Encourage regular and healthful exercise,
> C) Foster an aggressive and cooperative team spirit, increase the confidence of the individual, develop sportsmanship, and increase pride through participation in competitive athletics. (cited in Schellhous, pg. 14)

Just a bit more guidance was included in Air Force Manual 160-26, *Physical Conditioning*, published in 1956. The manual stated that it was the commander's responsibility to see that his men were developed physically, psychologically, and socially. A standard program was not established in this document.

A 1959 study (Balke and Ware in Schellhous, 1982), of fitness levels in the Air Force, found that the overall state was "poor," and declared that the Air Force physical fitness program was ineffective. AFR 50-5 was revised in 1959. Commanders were required to establish a physical conditioning program, establish weight limits, and prescribe regular weekly exercise. Still, no standard program or levels of fitness were established (Schellhous, 1982).

The increased national interest in physical fitness in the early 1960s led the Air Force to adopt the Royal Canadian Air Force Five Basic Exercise (5BX) Plan as its official fitness program. An Air Force Pamphlet AFP 50-5-1 regulated the program for men, and AFP 50-5-2 outlined the Ten Basic Exercise Plan (XBX) for women. The 5BX program was designed to work the skeletal muscles, heart, and lungs in a progressive manner until a given level of fitness was achieved. A specified number of repetitions of each of five exercises was to be completed within eleven minutes. In 1963, Air Force personnel and researchers from Indiana University reported that the 5BX program was fraught with problems, including a high failure rate, an unsatisfactory testing program, and a lack of emphasis on the importance of physical fitness (Schellhous, 1982).

Dr. Kenneth Cooper, an Air Force flight surgeon who is considered to be the founder of the aerobics movement, was behind the next iteration of the Air Force fitness program. The aerobics program provided semi-annual testing of all personnel. The test consisted of a timed 1.5 mile run. Taking into consideration the person's age and time, personnel were put into one of five fitness categories ranging from very poor to excellent. A number of fatalities during testing led the Air Force Surgeon General to modify AFR 35-11 in 1979. Personnel age 35 and over were tested using a 3-mile walk rather than the 1.5 mile run. This change was not popular, and by 1980, all personnel were permitted to run rather than walk for the annual fitness test. In 1981, AFR 35-11 indicated that members to be tested annually could choose the 1.5 mile run, the 3-mile walk, or stationary running. In March 1982, the Air Force began assessing the stationary bicycle to estimate work capacity, which led to the current Air Force cycle ergometry program.

3.3.3 Current Air Force Fitness Standard

The current Air Force fitness standard does not mandate duty time for physical fitness. Individual commanders can require on-duty physical training, but for the most part, physical training appears to be voluntary and the responsibility of the individual. The Air Force Fitness Program office uses cycle ergometry as its main physical fitness assessment tool. The current cycle ergometry test was implemented in October 1992. All Air Force personnel take this test once a year. Cycle ergometry is used because it is a reliable and safe estimate of cardiovascular fitness. It is a submaximal test, based on the physiological principle that heart rate increases as work intensity and oxygen consumption increase. The individual's heart rate is used to estimate VO_2max. As an adaptation to physical training, heart rate is expected to decrease for a given level of workload. This test has demonstrated its correlation with the graded treadmill test (Pollock et al., 1994). The testing procedure assesses heart rate at the end of a six-minute steady-state cycling period. Minimum passing heart rates are established by sex and age. In its current iteration, the test is graded pass or fail only.

3.3.4 Comparison with Standards of Other Forces

Table 2, *Comparison of Fitness Programs for Military and Other Government Organizations*, presents the fitness activities of several organizations whose missions are similar to that of the Air Force. (Sources of information appear on the table.) Included organizations are the US Army, US Navy, US Marine Corps, the Secret Service, the FBI, and the Royal Australian Air Force. This section summarizes the main points and motivations behind these fitness programs; see the table for full details. In this section, the philosophy behind each agency's program is discussed, then the testing program is summarized, and finally, the training program, if any, is documented. If any rationale for the choice of measures was provided, that is stated as well.

Table 2. Comparison of Fitness Programs for Military and Other Government Organizations

Issue	Service or Agency Requirements						
	US Military				US Non-Military		Foreign Military
	US Air Force[1]	US Army[2]	US Navy[3]	US Marine Corps[4]	Secret Service[5]	FBI[6]	Royal Australian AF[7]
Physical Conditioning Program							
Fitness Training		Yes	Yes	Yes	Yes	Yes	
Mandatory			Yes	Yes	No	No	
Medical Qualification for Participation				Yes		Yes	
Qualifying Personnel				All Marines			
Frequency			3 Times Per Week	3 Hours Per Week	3 Hours Per Week	3 Hours Per Week	
Conducted During Duty Time		Yes	Yes	Yes	Yes	Yes	
Required Log/Record of Activity						Yes	
Purpose							
Maintain Physical and Mental Stamina			Yes				
Support Operational / Combat Readiness			Yes	Yes			
Health and Well-Being				Yes		Yes	
Day-to-Day Effectiveness				Yes		Yes	
Self-Confidence				Yes			
Increased Productivity						Yes	
Physical Fitness Testing							
Physical Fitness Test	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Personnel to be Tested	All USAF Personnel	All Officers and Enlisted Personnel	All Personnel Under Age 50	All Marines Under 46 Years of Age	All That Carry Weapons	All Agents	
Mandatory	Yes	Yes	Yes	Yes	No	Yes	Yes
When Conducted	Annually	Semi-Annual	Semi-Annual	Semi-Annual	Semi-Annual	Semi-Annual	
Purpose							
Increase Productivity	Yes						
Maintain / Enhance Combat Readiness	Yes	Yes					Yes
Decrease Health-Related Expenditures	Yes						
Evaluate Physical Fitness		Yes		Yes			
Health and Well-Being					Yes		
Maintain Level of Fitness Required to Perform Job Duties					Yes		Yes
Self-Analysis						Yes	
Performance Measures							
Running		2-Miles		1.5-Miles (Females); 3-Miles (Males)	1.5-Miles	1.5-Miles	
Walk/Run			1.5-Miles				
Walk or Run							3-Mile Walk or 1.5-Mile Run
Push-Ups		2-Minutes	2-Minutes		1-Minute	Maximum	
Sit-Ups		2-Minutes		Bent-Knee	1-Minute	1-Minute	Yes
Curl-Ups			2-Minutes				
Pull-Up / Chin-Up				Yes (Males)	1-Minute		
Chin-Up / Flexed-Arm Hang							Yes
Flexed-Arm Hang				Yes (Females)			
Sit & Reach			Yes		Yes	Yes	
Swim Test					Yes		
Cycle Ergometry	Yes						
Alternate Aerobic Events							
Bicycle		6.2-Miles					
Walk		2.5-Miles					
Swim Test		800-Yds.	500-Yds				
Performance Evaluation							
Rank / Score Based on Gender	Yes	Yes	Yes		Yes		
Rank / Score Based on Age	Yes	Yes	Yes	Yes	Yes	Yes	
Must Obtain Minimum Requirement Measures in All Events		Yes		Yes			
Actions Upon Failure							
Required Reassessment	Yes	Yes					
Self-Directed Physical Conditioning Program	Yes						
Monitored / Supervised Physical Conditioning Program	Yes		Yes	Yes			
Administrative Action	Yes						
Potential Separation from Service		Yes					
May Affect Advancement			Yes				

Adapted from:

[1]Anderson, E. R. (1996, February 1). Air force instruction 40-501: The air force fitness program. Bolling, AFB: HQ AFMOA/SGO.
[2]Department of the Army. (1993, October 29). *USAMRDC memorandum number 350-15*. [WWW Document] URL http://mrmc-www.army.mil/mrmc_library/memorandum/350-015.MEM
[2]SUNY Brockport Army ROTC (n/d, 1997). *The army physical fitness program*. [WWW Document] URL http://www.acs.brockport.edu/~jmcclell/apft.html
[3]Hernandez, R. S. (1996, Sept). *Health and physical readiness*. Minutes of the 1996 U. S. Air Force Fitness Summit III, Attachment 9 Briefing Slides 1-24.
[4]Department of the Navy. (1988, February 29). *Marine corps order 6100.3J*. [WWW Document] URL http://www.usmc.mil/opages/pft.htm
[5]Emmett, D. (1997, January 27). *Telephone conversation and faxed materials from Secret Service Fitness Coordinator.*
[6]Kortyka, F. (1997, January 22). *Telephone conversation and materials received from Federal Bureau of Investigation Fitness Coordinator.*
[7]Telford, D. (1996, May 16). *Physical fitness in the RAAF*. [WWW Document] URL http://www.adfa.oz.au/DOD/RAAF/news/may96/fitness.html

3.3.4.1 US Army

The Army conducts field tests of aerobic fitness, muscle strength, muscle endurance, and measures body weight, twice a year. Such tests are conducted by Army units without the use of equipment or indoor facilities. The Army Physical Fitness Test (APFT) (Vogel, 1986) is administered to all personnel through age 60: individuals 40 years of age and older receive a pre-test physical and coronary risk assessment.

The current set of tests were chosen on the basis of ease of administration and objectivity of scoring and lack of needed equipment (Vogel, 1986). The three events are a timed two-mile run, the maximal number of extended-leg push-ups within two minutes, and the maximal number of bent-knee sit-ups within two minutes. When needed, acceptable substitutions for the two-mile run are a 6.2-mile bike ride, a 2.5-mile walk, or an 800-yard swim. Scoring differs by age and sex.

For enlisted personnel and NCOs, physical training each morning is mandatory. For the most part, officers are responsible for their own physical conditioning program, although whether this is voluntary or mandatory varies from post to post.

Vogel (1986) reports that the Army's two-mile timed run is a good estimate of aerobic fitness, but push-ups and sit-ups leave something to be desired as measures of general strength. The report also states that both of these events should be considered primarily strength endurance measures that are limited to shoulder and abdominal muscles. While neither of these tests correlate well with common soldiering tasks, they serve to stimulate physical training program activity.

3.3.4.2 US Navy

The Navy's physical readiness program is designed to "maintain optimal health and the physical and mental stamina required to operate efficiently in diverse environments, to support operational readiness" (Bureau of Naval Personnel, Pers-601). The Navy's Physical Readiness Test (PRT) assesses body composition, aerobic fitness/endurance, muscular endurance, and flexibility. The fitness components are tested using a 1.5 mile run/walk (or 500-yard swim), maximum number of curl-ups in 2 minutes, maximum number of push-ups in two minutes, and the sit-reach test of flexibility. The same tests are administered to men and women up the age of 50 years; scoring standards are gender- and age-adjusted. In 1994, a requirement for mandatory exercise was implemented by NAVADMIN 148/94 (Navy News Service, 1994). It specifies that commanding officers make three-times-weekly exercise mandatory for all hands unless operational commitments make implementation impossible. Exercise sessions should include at least 20 minutes of aerobic activity, strength and flexibility training, plus a warm-up and cool-down.

Job-relevant training programs are being developed by the Naval Health Research Center in response to the DoDD 1308.1, which ordered each military Service to develop training programs to meet the specific task requirements of their personnel. One such total body fitness program is SPARTEN (Scientific Program of Aerobic and Resistance Training Exercise in the Navy). SPARTEN is an on-ship program which is based on research findings indicating that aerobic and circuit training is superior to aerobic and calisthenic conditioning for developing total body

fitness. It offers aerobic training to maintain health and progressive resistance training which optimizes job performance and minimizes job-related injuries (Marcinik, 1984). The movements simulate efforts such as lifting, pushing, and pulling which are performed during the performance of muscularly demanding shipboard work. The circuit weight training exercises are performed on a multi-station machine and develop all major muscle groups. The exercises are performed in rapid succession to develop cardiovascular endurance.

3.3.4.3 US Marine Corps

The Marine Corps Physical Conditioning Program is designed to promote everyday work effectiveness, combat readiness, leadership, and self-discipline. Marine Corps testing, administered twice a year, differs for men and women. Women and men run for three miles. Both sexes perform bent-knee situps. Women do a flexed arm hang while men perform pull-ups/chin-ups. The run is used to measure the efficiency of the cardiovascular system, and the other events are designed to test the strength and stamina of the upper body (shoulder girdle), midsection, and lower body.

The Marine Corps Order 61003J states that all Marines will participate in a minimum of three hours of physical fitness training per week. A successful Physical Conditioning Program is said to consist of the following types of exercises: anaerobic conditioning, progressive resistance training, and aerobic conditioning.

3.3.4.4 Royal Australian Air Force

The Royal Australian Air Force (RAAF) Physical Fitness Test indicates the basic level of fitness necessary for operational deployment. It is "sub-maximal in nature to measure minimum requirements rather than maximal performance and so reduce any health risk to susceptible individuals associated with test of maximal exertion."

Components are the chin-up or flexed-arm hang which tests upper body strength and muscular endurance. The standards are not meant to reflect maximal capacities but rather establish that personnel have the capacity to hoist themselves over an obstacle or into an aircraft from a hanging position. The sit-up test requires that personnel possess the minimum standard of abdominal strength and endurance. It indicates that the pelvic girdle posture is well serviced by abdominal muscle group. "Maintenance of good posture around the pelvis and lower back is an important contributor to most forms of physical performance, including running and walking, especially when carrying a back pack. Moreover, adequate abdominal fitness reduces the risk of back injury, a common ailment not only in the RAAF but in the community in general" (Telford, 1996, p. 1).

The 2.4 km run/5 km walk test requires performance at the minimum standard of cardiovascular fitness, specific to locomotion by foot. The RAAF considers aerobic fitness to be the basis of general physical fitness and closely related to general health.

3.3.4.5 Federal Bureau of Investigation

The FBI physical fitness requirements are based on the belief that all personnel should be ready even if that readiness is not required. The FBI also believes that healthy workers are productive workers. Tests are administered to all personnel twice a year.

Testing consists of a five-minute step test, maximum number of situps in one minute, maximum number of pushups without a time limit and one-and-one-half-mile run that is timed, and a sit-and-reach flexibility test. Scores take age into account.

Three hours per week of work time are allowed for physical training, and personnel must keep records of their activity.

3.3.4.6 Secret Service

The Secret Service Fitness Coordinator reports that physical fitness training and testing ensures a force that is healthy in order to decrease days off and medical costs, and a force that has a level of fitness required to fulfill the job. The fitness test is administered to all personnel who carry weapons, twice a year. The fitness test consists of sit-ups, pull-ups, push-ups, a mile-and-a-half run, the sit-and-reach test, and body fat measurement. Scoring takes into account age and gender.

Three hours of duty time per week are allotted for working out.

3.3.4.7 Other Organizations

Other organizations with young adult populations have tests similar to those in Table 2. The following information is just a sampling of organizations whose standards were easily accessed during the preparation of this report. The time-consuming nature of gathering information, often not available in the published literature, about testing programs of organizations prevented a comprehensive survey. Examples of programs with a balanced fitness program include Virginia Military Institute (Allison & Bradley, 1996), the Civil Air Patrol (Civil Air Patrol, 1997), and the Cooper Institute for Aerobic Research (Cooper Institute for Aerobic Research, 1997).

- Virginia Military Institute
    - five pull-ups
    - 60 sit-ups in two minutes
    - 1.5 mile run in 12 minutes
    - same test and standards for males and females

- Civil Air Patrol (US Air Force Auxiliary)
    - 1-mile run
    - modified sit-ups
    - sit-and-reach

- The *FITNESS*GRAM, used by many organizations and designed by the Cooper Institute for Aerobics Research
    - to assess aerobic capacity
        - run or walk/run
    - to assess abdominal strength
        - curl-up test
    - to assess trunk extensor strength and flexibility
        - trunk lift
    - to assess upper-body strength (choose one)

    - 90 degree push-up
    - pull-up
    - flexed arm hang
    - modified pull-up
- to assess flexibility (choose one)
    - back-saver sit-and-reach
    - shoulder stretch

3.3.5 Comparison of Air Force Fitness Program with Recommendations of Programs between 1965-1996

Table 1 surveys the recommendations for fitness activities of several national health and fitness organizations. This information is emphasized here so that the Air Force's fitness program can be compared with the recommendations of major relevant associations. Table 1, adapted from the US Surgeon General's report on fitness (US Department of Health and Human Services, 1966) reveals that groups such as the YMCA, the American College of Sports Medicine, the American Heart Association, and the American Association for Cardiovascular and Pulmonary Rehabilitation have specific recommendations regarding strength training activities. Also, flexibility exercises are promoted by the American College of Sports Medicine, the YMCA, the Surgeon General, the American College of Sports Medicine, and the US Preventive Services Tasks Force. In comparison with these recommendations, the Air Force's fitness requirement is one-dimensional. That is, the Air Force's test is limited to aerobic assessment, and while this is meant to be a barometer of overall fitness, the focus of the program is still seen as limited.

3.4 CONCLUSION

The literature surveyed regards balanced fitness to be true fitness. Balanced fitness incorporates five components: body composition, cardiovascular fitness, muscle strength, muscle endurance, and flexibility. Compared to this description, the AFFP focuses on body composition and cardiovascular fitness but not on muscle strength, muscle endurance, or flexibility.

A look at the recommendations of national health and fitness organizations and the fitness programs of other military and government organizations, most of which incorporate strength testing, and some of which also recommend flexibility evaluation, reveals that the Air Force's Fitness Program is relatively narrower than most in its focus.

4.0 STRENGTH AND STRENGTH TRAINING

Section 3.0 compared the Air Force Fitness Program with current definitions of fitness, and with recommended fitness programs. Since accepted definitions of fitness include strength training, and since many organizations promote strength training, Section 4.0 will focus on strength training and how stronger personnel might benefit the Air Force. This section defines strength and strength training, gives views of subject matter experts on the topic, reiterates the national programs which promote strength training, and documents specific benefits of following a strength training program.

4.1 STRENGTH DEFINED

Strength is assessed by measuring the capability of a muscle to exert a maximal force against resistance. Muscle endurance is the capability of that muscle to exert force repeatedly, over some period of time. While strength and muscle endurance are considered to be separate components of fitness, they are often discussed together, since training for strength also contributes to muscle endurance, and when training for muscle endurance, strength is often increased. As opposed to the training of Olympic weight lifters, for whom the development of strength for a one-lift competition is a goal, from the perspective of the Air Force, both strength and muscle endurance are necessary for the conduct of daily activities and the performance of deployment tasks. Knapik (1989) says that studies of the relationship between absolute muscle endurance (the ability of a muscle to repeat high-intensity, submaximal contractions with a fixed load) and muscle strength show high correlations, between 0.76 and 0.95, implying that those who have high muscle strength also have high absolute endurance. Knapik states:

> In a military environment, it is the absolute endurance that is important. . . . Thus, for military purposes it is possible to combine the concepts of muscular strength and endurance since they are highly related on an absolute basis. The term 'muscular strength/endurance' is appropriate. (p. 328)

What is strength training? In their 1997 book, *Designing Resistance Training Programs*, Fleck and Kraemer state that, "The terms strength, weight, and resistance training have all been used to describe a type of exercise that requires the body's musculature to move (or attempt to move) against an opposing force, usually presented by some type of equipment" (p. 3). The National Strength and Conditioning Association (cited in Duda, 1990) says:

> Strength training is the use of progressive resistance methods to increase one's ability to exert or resist force. This type of training may utilize free weights, the individual's own body weight, machines, or other devices to attain this goal. In order to be measurably effective, the training sessions must include timely progressions in intensity, which provides sufficient demands to stimulate strength gains that are greater than those associated with normal growth and development. (p. 50)

The terms strength training and resistance training are used almost synonymously, and include any measure used to resist or bear force, such as the use of free weights and weight machines, exercising against a large rubber band, and some calisthenics. Weight training is a type of strength training which incorporates the use of free weights such as barbells, and weight machines. An extensive review of the types of resistance modalities (isokinetic, variable resistance, isometric) and of different training systems can be found in Fleck and Kraemer (1997) and Baechle (1994).

4.2 SUBJECT-MATTER EXPERTS – THEIR VIEWS ON STRENGTH TRAINING

One way that the Air Force can assess the appropriateness of adding a strength component to their fitness recommendations is to evaluate the sentiment toward strength training on the part of the fitness, sports physiology, and sports medicine community. This *Review & Analysis* culled the popular literature (magazines, Web sites, news releases, and books) to garner these opinions about strength training. There is a preponderance of evidence that strength is a vital part of a person's achievement of balanced fitness. James Garrick, MD, of the San Francisco Center for Sports Medicine states:

> There's a lot more to enhanced fitness than improved cardiovascular function. That's the one everyone talks about, but there's more to life. It doesn't do much good to be able to run across the concourse of the airport to catch a plane if your shoulder hurts for two weeks afterward from carrying your carry-on bag. (cited in DeMarco, 1990, p. ix)

Echoing the sentiment that balanced fitness is essential is Dean Brittenham (cited in Duda, 1990) of the Center for Athletic Development at the National Institute for Fitness and Sport in Indianapolis, who states:

> The human body is an amazing machine and it needs a total fitness program. . . . The thing that wears out fastest is the heart, so that should be the focus of exercise programs. . . . But to exercise the heart muscle best we need to develop the entire muscular system surrounding it. (p. 49-50)

Steven Fleck, a sports physiologist with the US Olympic Committee, states:

> During the 1970's and 80's 'aerobics' was the battle cry of the fitness craze. And indeed, aerobic or endurance training does result in increased cardiovascular fitness and its associated health benefits. However, cardiovascular fitness alone should not be understood to mean 'balanced' or 'total fitness.' You've probably known a person who ran, swam, or cycled religiously but who lacked the flexibility to bend over and touch their toes or the upper body strength to carry their luggage through the airport. Aerobic exercise is great for increasing cardiovascular fitness but it does not necessarily lead to increased flexibility, strength, or power. (Fleck, 1990, p. 63)

The Army applauds the growing trend toward the inclusion of strength training in a balanced fitness program. An on-line book, *Executive Wellness, A Guide for Senior Leaders* (Richardson, 1997), from the US Army Physical Fitness Research Institute, states:

> For many years, fitness was a term applied only to aerobic and flexibility exercises. Exercise and fitness programs have often disregarded the importance and usefulness of strength training, particularly with advancing age. Fortunately, strength training is now becoming a crucial component of well-rounded exercise programs for all ages, both males and females. (p. 1)

In an article entitled, *Move Over Aerobics, Endurance, Muscle Strength are Coming Back,* Kitty Runzheimer (1985), who directs one of the nation's busiest YMCA facilities, describes the trend in the YMCAs toward basic calisthenic and weight training programs. She states, "More and more people are beginning to realize that physical fitness is more than just aerobics. Muscle strength and endurance are equally vital elements of every fitness workout" (p. G-16). She cites a 1984 Lou Harris poll showing that calisthenics is one of the fastest growing fitness activities, both as a warm up for other events and as an activity in itself. Seeing a tremendous growth in her YMCA membership's interest in classes that promote muscle strength and endurance, and documented improvements in strength and body girth, Runzheimer hears comments like these:

> "I thought the only way I could feel better was through increasing my aerobic capacity. Now I realize that I can also have that same healthy feeling through increased muscle strength."
>
> "I've reshaped my body through this class."
>
> "My back has never felt better." (p. G-16)

Runzheimer lists these benefits of increasing muscular strength and endurance:

- It improves the ratio of lean body mass to fat tissue, leading to a trim body with well-toned muscles throughout.
- It results in fewer exercise injuries.
- It provides strong joint actions that enable one to pursue aerobic fitness and recreational and sports activities.
- It works to eliminate muscle imbalance.
- It is necessary for good posture.
- It keeps all muscles and joints working smoothly, maintaining basic coordination with greater ease.
- It lets one feel better about oneself. (p. G-16-17)

Runzheimer summarizes her feelings about the importance of quality fitness workouts to improve muscle capacity by stating, "A sound strength and endurance training system is essential for building a strong total body support structure to prevent injuries, to maintain correct posture, to improve physique, and to achieve a feeling of total well-being." (p. G-17)

Dr. Wayne Westcott, exercise physiologist and strength training consultant to the YMCA of the USA, states that strength training is increasingly important as we age. He says, "Because our muscles are the engines of our bodies, this loss of muscular components has a major impact on our physical ability and functional capacity. In essence, we go from an eight-cylinder engine, to a six-cylinder engine, to a four-cylinder engine" (Richardson, 1997).

Dr. Michael Pollock (cited in Richardson, 1997), director of the Center for Exercise Science at the University of Florida, and the chair of the American College of Sports Medicine committee that revised that organization's fitness prescription, says, "Strength training increases range of joint movement, increases muscle mass, strengthens bones, muscles, tendons, ligaments, improves your ability to do everyday chores and activities, improves health and fitness, helps prevent accidents, injuries, and sickness, and speeds rehabilitation when you do get hurt" (p. 1). Pollock asserts that "strength training helps tone, shape and strengthen muscle fibers, minimizing the 'fatty marbling' within the muscle which results in a flabby, weak muscle. Equally as important, having more strength and endurance makes daily activities easier and less tiring, thereby increasing or maintaining stamina" (p. 1).

The Surgeon General also recommends in general that muscular strength and flexibility be part of one's overall activity program (U. S. Department of Health and Human Services, 1996), stressing that these components will help the ability to perform tasks and to reduce the potential for injury.

Dr. Robert Cooper, in his book, *Health and Fitness Excellence* (Cooper, 1989), states:

> More than four hundred muscles keep your body firm—or let it sag. If those muscles aren't made strong and balanced in relationship to each other, and kept that way through a weekly fitness program—they slowly wither as time goes by. . . . Aerobic fitness programs build strength and endurance too, sometimes in isolated body areas. . . . But we each need to take additional steps to guarantee that we're shaping and toning all four hundred skeletal muscles, not just a handful. (p. 193)

4.3 RECOMMENDATIONS OF NATIONAL PROGRAMS AND PROGRAMS OF MILITARY AND OTHER GOVERNMENT ORGANIZATIONS

Section 3.2.3.1 describes in detail some of the national programs that include strength training in their exercise prescriptions. Especially important as an authority on fitness is the message from the American College of Sports Medicine (1990), which includes a recommendation for strength training activities of a moderate level. Their specific recommendation is one set, 8-12 repetitions of 8-10 exercises two days a week. The US Surgeon General (Department of Health and Human Services, 1996) also advocates strength training, specifically, at least twice weekly performance of one to two sets of 8-10 strength-developing exercises, with 8-12 repetitions. The US Department of Health and Human Services Healthy People 2000 also recommends activities which promote muscle strength as part of an overall fitness plan (Wier, 1992). As discussed in Section 3.3.4, all of the other military and government organizations included in Table 2 test for either muscle strength, muscle endurance, or both.

4.4 SPECIFIC BENEFITS OF STRENGTH TRAINING

The quotes by subject-matter experts indicate the myriad of benefits that can be accrued through strength training. This section looks at these variables in finer detail. First, some consideration is given to how military readiness and the performance of everyday tasks might be affected by strength training. Then the scientific and technical literature is summarized, both pro and con, regarding health-related variables thought to be affected by strength training, such as maintenance of muscle mass and prevention of osteoporosis. Implications for the Air Force of each of these benefits is emphasized at the end of each section, and if aerobic training provides an adequate or superior benefit, a note is made of that.

4.4.1 Deployment Readiness

Consideration needs to be given to the performance of basic military tasks, as presented in the beginning section of this *Review & Analysis*. Besides units who are prepared for deployment by virtue of their daily physical tasks (maintenance crews, some civil engineering units, for example), Air Force personnel who are not normally required to perform physically demanding tasks might be called upon to do so on a moment's notice. Such tasks as moving an injured comrade, performing in nuclear/biological/chemical gear, erecting tents, and transporting and loading medical and personal equipment, are all tasks that might conceivably be required of an Air Force person who was not normally required to perform a task requiring a great deal of physical effort. Army Maj Hertling (1987) argues that strength training is essential to combat-specific tasks. He explains:

> In order to be effective, physical training must be specific to those tasks a soldier is expected to perform in combat. A program based on extensive aerobic activity may help the corporate executive maintain his fitness level, keep his weight down and stave off a heart attack, but jogging only provides a cardiovascular fitness base and will have little influence on someone who needs stamina or short bursts of energy in a combat situation. (p. 8)

Implication for the Air Force: Troops whose strength training mirrors the kinds of actions that might be required during deployment will be better able to function in emergency conditions. Especially to be considered are personnel who are not required to do physical labor in their everyday jobs, but who may be called upon in time of national emergency to do so.

4.4.2 Everyday Tasks

Adequate strength to do a specific Air Force job is determined through the Air Force's Strength Aptitude Test (Ayoub, Jiang, Smith, Selan, & McDaniel, 1987). This test is an incremental lift test which qualifies enlistees for jobs demanding heavy physical work. The concern in this section, however, is to establish in a more broad sense how general physical fitness allows work to be done more safely and efficiently. Adequate muscle strength lets us work more efficiently and therefore more productively, since our energy is being preserved. Wayne Westcott, Ph.D., a strength training consultant to the National Academy of Sports Medicine, the YMCA of the USA, and the American Council on Exercise, emphasizes that a person who is strong uses less

effort to walk or push a pedal. The more energy a person saves, the greater endurance that person will have (Westcott in Eller, 1996). An example of how increased anaerobic capacity helps in everyday life, cited by Stone, Fleck, Triplett, and Kraemer (1991) is of a longshoreman lifting heavy boxes from the floor to a shelf. Compared to someone who was not fit, a stronger longshoreman would fatigue less rapidly because he would be performing at a lower percentage of his maximal strength.

Another viewpoint, that the safe completion of everyday tasks ought to be one of the goals of a fitness program, is cited by fitness expert Maxine Rock who states:

> In everyday life, most of us work at top capacity for short periods of time on such tasks as . . . carrying luggage. Strength training duplicates real-life performance with resistance from barbells, machines, and body weight. (Rock,1990, p. 126)

Besides deployment readiness and the efficient and safe production of everyday tasks, there are several health benefits associated with strength training.

Implication for the Air Force: Strength training helps prepare the body for everyday tasks which require physical effort. A strong body will allow the efficient and safe production of a day's work.

4.4.3 Body Composition

Strength training increases muscle mass and decreases fat mass. As people age, it is increasingly important to participate in weight training in order to maintain muscle mass. "There's only one way to stop your muscles from wasting away: strength training. It doesn't matter if you're 40 years old or 75 years old. If you don't build muscle, you'll lose muscle," is the belief of Dr. William Evans, of Pennsylvania State University (cited in Richardson, 1997, p. 1). The main reason that most of the adult population needs to perform resistance activity using weight machines, free weights, or rubber bands is that daily tasks do not provide sufficient stimulation for muscle building or even maintenance. Muscles get weaker as time goes by because of general aging and a reduction in tasks that place physical demands on us. Between the ages of 20 and 70, we lose about 30% of our muscle mass, with that averaging several pounds of muscle per decade. This rate of loss accelerates after the mid-40s (Brehm, 1993). Another estimate is that we lose a half-pound of muscle every year from our 20's on (Livermore, 1990). This means that several pounds of muscle are lost every decade. After the age of 40, the rate of muscle loss increases.

Although some of this muscle atrophy is due to aging, most of it is not. Muscle atrophy to a large extent can be prevented by strength training (Brehm, 1993). Convinced that inactivity and not age is the cause of loss of muscle mass, Dr. Evans (cited in Richardson, p. 3) says, "If you correct muscle strength losses for lost mass, there is no loss of strength per unit of remaining muscle." This means loss of muscle mass, probably due to lack of use, is the problem, not age. Proving that the loss of muscle mass with age is dictated more by disuse than general aging are studies which showed increases in muscle strength in elderly men from a brief weight training program. The *Journal of the American Medical Association* reports that a group of men in their ninth decade increased their lower extremity strength from 61% to 374% after eight weeks of strength training. Another group of elderly men doubled their leg strength by participating in a

12-week weight lifting program (cited in Richardson, 1997). The *Journal of Applied Physiology* (Treuth et al., 1994) reports that a 16-week strength training program resulted in increased regional and total lean mass and decreased regional and total fat mass in middle-aged and older men.

Aerobic exercise, which implies contracting the muscles repetitively with little or no resistance, does not prevent loss of muscle mass (cited in Richardson, 1997). Dr. Evans says, "Runners lose muscle mass even if they're highly active" (p. 3).

Closely related to muscle mass is fat mass. This relationship is explained by Dr. Jack Wilmore at the University of Texas, who states (cited in Richardson, 1997) that the loss of lean muscle leads to the "creeping phenomenon" of body fat. "Someone who gains 30 pounds of body weight may have really lost 15 pounds of muscle and gained 45 pounds of fat" (p. 2). Strength training can counteract this slowdown since it builds muscle mass." Body fat can be reduced through strength training. Highly related to the acquisition of muscle mass and increased metabolic function, strength training is effective in a weight loss program where the goal is not just to lose weight but to lose fat mass. One study compared the efficacy of a strength training plus aerobics program vs an aerobics-only program, for participants who were on a reduced calorie diet of 20% fat, 20% protein, and 60% carbohydrate. All participants exercised three times a week for 30 minutes. Westcott, the study's author (cited in Livermore, 1990) stated that the aerobic-only group lost 3.2 pounds of fat, while the strength training and aerobic group lost an average of 10 pounds of fat. (Individuals in this latter group gained two pounds of muscle, while members of the aerobic-only group lost about a half pound of muscle.) Regarding strength training, Westcott states, "There is no better way to lose fat and enhance strength and fitness." (cited in Livermore, 1990, p. 108)

Implication for the Air Force: Strength training programs will produce increased strength, increased muscular fitness, increased lean muscle mass, decreased body fat, and increased bone mass.

4.4.4 Basal Metabolic Rate

A concomitant issue to amount of muscle mass is a reduction in basal metabolic rate which follows when muscle mass is lost. That is, when muscle mass and strength decline, so does basal metabolic rate, the amount of energy expended by one's body at rest. BMR affects how quickly calories are burned. BMR is partly a function of fat-free mass, since fat cells have a low metabolic rate. Therefore, muscle mass exerts a great deal of influence on BMR, because muscle cells are metabolically active even when a person is not exercising. As the body loses muscle, fat-free mass is reduced, and the body needs to expend less energy to keep the machine going. Brehm (1993) says that BMR declines by about two percent each decade after age 20. Other sources document reductions between 2 and 5 percent in resting metabolism per decade (Richardson, 1997). Livermore (1990) estimates a half-percent loss in rate each year.

Strength training can counteract this slowdown since it builds muscle mass. Increased resting metabolic rate can still occur for several hours after exercise is completed. Four hours after exercising, one study found increases in resting metabolism from 7.5 to 28 % higher after a vigorous workout, compared to non-workout days (Richardson, 1997).

Aerobic activity has a beneficial effect on BMR as well. Prateley et al. (1994) used a 16-week resistance training program with a population of men in their fifties and sixties. Resting metabolic rate (RMR) did increase on an average of 7.7%. Fat-free mass decreased as well, but an increase in sympathetic nervous system activity may have contributed to the increase in RMR also. They authors note that a similar increase in RMR occurred in an experiment in which the activity was aerobic, and for which there was no change in fat-free mass.

Implication for the Air Force: Strength training, probably largely through its effect on muscle mass, can increase rates of resting basal metabolism, which is a benefit in controlling body weight. However, aerobic activity has been shown to produce a similar effect, without a concomitant change in fat-free mass.

4.4.5 Bone Mass and Osteoporosis

Osteoporosis, a decrease in bone density, especially affects women as they age. Since the amount of bone mass present at retirement will influence future bone mass, a fitness requirement that influences bone mass of active-duty Air Force will affect the future health of the retired Air Force population. By age 65, one-third of all women will have a fracture of spinal bone, and one of every three women and one of every six men will have a hip fracture (Nieman, 1995). Strength training may prevent osteoporosis, since people with stronger muscles tend to have stronger bones (Brehm, 1993). Osteoporosis is a decrease in bone mass which leads to fractures. It appears that resistance training can increase bone mass. Involving the bones in load bearing activity or in forceful muscular contractions increases bone mass (Duda, 1990) The stimulus applied through strength training stresses the bone to increase bone mineral content (Richardson, 1997).

Although cross-sectional studies show this relationship more strongly than intervention studies, most research studies do document the relationship between weight-bearing exercise and increased bone density. Nordstrom, Thorsen, Nordstrom, Bergstrom, and Lorentzon (1995) document the relationship between hamstring strength and bone mineral density in adolescent boys. Bone mineral density was also shown to improve over an 18-month strength training program with women between the ages of 35-45 (Heinonen et al., 1996). Bone mineral density was superior for a group of elderly women who performed strength training twice a week for six months, compared to controls who did not exercise (Hartard et al., 1996).

Fitness experts agree on the benefits of strength training for bone density. Kenneth Cooper, who helped design one of the earlier Air Force Fitness Programs, and the person who is known as the founder of aerobics, speaks to this benefit of strength training in an article with Sydney Bonnick:

> Medical research has now proven that strength training can have an extremely beneficial effect on bone mass . . . and may play a role in the prevention of osteoporosis. (Cooper & Bonnick, 1990, p. 24)

These authors go on to state that the treatment of osteoporosis is difficult, and the best approach is prevention. Prevention consists of developing the greatest bone mass possible and then maintaining that bone to the highest possible degree. Exercise can encourage the development of bone mass before age 30, the age when peak bone mass is attained. Findings from the NASA space program that weightlessness affected bone mass reinforced the belief that exercise was

important in the maintenance of bone mass. Subsequent evidence from a study of leg bone strength among professional athletes, amateur athletes, recreational athletes, and non-exercisers indicated that professional athletes and world class athletes had stronger lower leg bones than recreational athletes and non-exercisers. Recreational athletes had greater leg bone strength than non-exercisers, and the relative strength among recreational athletes varied as a function of the type of activity they engaged in. Weight lifters had the strongest bones, followed by runners, soccer players, and swimmers. The exercises which created the greatest load on the bone were the most effective in increasing bone strength. These and other studies cited by Cooper and Bonnick (1990) indicate that bone mass in the spine, arms, and legs, of men and women, can be increased using strength training with free weights and resistance machines, as well as running, since it is a weight bearing activity. The strongest bones were found in men and women who performed a balanced fitness program which involved both aerobic and strength training. Benefits are not limited to the young, and increases in bone strength have been seen with exercise programs of people who are in their seventies.

There seems to be a some evidence that many types of physical activity promote bone density, not just strength training, but there is also some opposing research. Studies by Nelson et al. (1991) and Cavanaugh and Cann (1988) failed to find such an association between walking and bone density increases. The Surgeon General's report regarding the benefits of exercise in general vs resistance training for the prevention of bone loss, states, "...it is unclear whether muscle-strengthening (resistance) activity may be more effective than endurance activity for this purpose" (U. S. Department of Health and Human Services, 1996, p. 132).

Implication for the Air Force: Strength training can help maintain, and in some cases, build bone density. This needs to be a special emphasis for the Air Force as more women serve in the military, since they are particularly affected by bone density loss. Increased bone mass through strength training could help reduce the rate of fractures of active-duty military, and could decrease the long-term crippling and associated medical costs associated with an aging population seeking military medical care.

4.4.6 Prevention of Injury

Strength training prevents injury in many ways. Strength training provides general protection against trauma since stronger muscles protect the joints they cross (Stone et al., 1991). Brittenham (cited in Duda, 1990) says that strong muscles can lessen the severity of an injury, with muscles protecting a bony area such as a knee and thus able to withstand trauma.

But it is not only muscles that are strengthened with strength training. Muscles are invigorated during strength training, and connective tissue structures (tendons, ligaments and joint capsules) are improved as well. Making these joints stronger means that they are less prone to injury (Brehm, 1993). Duda (1990) says that increased muscle mass protects the joints, preventing wear-and-tear injuries such as tendinitis and arthritis.

To withstand injury potential during aerobic conditioning, strength training is a must. Yessis (1994) tells us that most aerobics-related injuries are of the overuse type—the result of continually doing the same movements with the same muscles, which places such stress on the joints and muscles that they can no longer withstand the force. Injury then results. He states, "It is important to understand that cross-training evolved mainly to prevent injury which typically occurs in aerobic activities that are repeated too often" (p. 193). To prevent such injury, the

muscles must be strengthened in both a general and specific sense. General strength training requires that muscles used in the aerobic activity be strengthened through many different exercises. With specialized strength training, exercises are used which duplicate the movements in the particular aerobic or sports activity. Yessis (1994) also states that it is important to remember that as one improves in aerobic capability, muscles will not be getting stronger. Strength training must be maintained as speed, distance, or duration of the aerobic activity increases. If strength training is discontinued, muscles will weaken and will be once again prone to injury. The Surgeon General's report (U. S. Department of Health and Human Services, 1996) as well encourages the addition of strength and joint flexibility in order to reduce the potential for injury during other activities. Concurring with this opinion is Fleck (1990), who states that:

> The incidence of injuries caused by overuse such as "tennis elbow" and "swimmers shoulder" is lower in athletes who strength train on a regular basis compared to athletes who don't perform any type of strength training. In addition, the reoccurrence of these injuries is less frequent. This lowered incidence of injury is probably related to the increased strength and power of the muscles, tendons, and ligaments which makes them more capable of tolerating stress. (p. 66)

Duda (1990) says that increased muscle mass protects the joints, preventing wear and tear injuries such as tendinitis and arthritis.

Since a balance of muscle strength is one of the goals of weight training, chances of injury during other activities is less. Balance refers to the development of a muscle and its antagonist, the muscle that opposes the action of the first muscle. The agility that comes with better musculature and the attendant improved coordination can help a person withstand a fall or other injury situation (Richardson, 1997). Another factor in everyday and sports safety is the improved coordination that comes with increased muscle strength. The effect of resistance training on four measures of motor coordination was assessed by Golding and Bos (1967) who found that there was a favorable effect on coordination with male subjects.

The Surgeon General's report states that, "physical activity, including muscle-strengthening (resistance) exercise, appears to be protective against falling and fractures among the elderly, probably by increasing muscle strength and balance" (U. S. Department of Health and Human Services, 1996, p. 132).

Implication for the Air Force: Strength training produces strong muscles, ligaments, and tendons, which serve as protection against injury during deployment, and everyday and sports activities. Especially important for the Air Force's current Fitness Programs is the belief that strong muscles developed through strength training are essential for the safe performance of aerobic activities and team sports.

4.4.7 Aerobic Benefit

Although strength training is typically considered to be an anaerobic activity, very time-intensive strength training may also yield some aerobic benefits. Duda (1990) cites the case of circuit training, in which weight training repetitions occur for about a half hour at a rapid pace, as

providing some small aerobic gains. However, Hickson Rosenkoetter, and Brown (1980) report no improvement in $V0_2$ max resulting from a heavy resistance training program that did not involve any circuit training.

Implications for the Air Force: Certain regimens of strength training may increase the aerobic conditioning of Air Force personnel.

4.4.8 Musculoskeletal Health

People who engage in strength training may notice improvement in musculoskeletal problems, such as back or shoulder pain caused by weak muscles (Brehm, 1993). Brittenham (cited in Duda, 1990) says that a well-developed trunk and torso can help prevent low-back pain, one of the most common ailments in our society. He states that developing trunk and torso muscles is a key component of his training programs, since nearly 70% of people with sedentary jobs suffer from low back pain. Stone et al. (1991) indicate that lower back pain or injury costs millions of dollars each year, and that strengthening the abdominal and lower back muscles and their supporting structures can alleviate many of these cases.

Related to injury prevention is the concept of agility, which is the ability to rapidly change the direction of the body or its parts (Stone et al., 1991). There is a strong relationship between agility and the ability to generate maximum power and strength. Stone cites several studies which document that agility may be enhanced by increasing muscular strength and power.

Implication for the Air Force: Strength training could alleviate many common musculoskeletal complaints which require time off from work and costly medical treatment.

4.4.9 Flexibility

Although many still posit that strength training hinders flexibility, others believe that strength training improves flexibility. Semenick (cited in Duda, 1990) states that if muscles are exercised through the full range of motion, flexibility of the lower back and other areas will increase, noting that contrary to popular opinion, weightlifters are more flexible than the general population. The health benefits of being flexible are considered in the next section. As a safety issue, increased flexibility can have a beneficial effect for players of contact sports (Stone et al. 1991). A blow to an inflexible joint can tear a muscle or connective tissue. Stone et al. say that the exact relationship between flexibility and injury is not known, but there is empirical evidence that contact and overtraining injuries can be reduced in terms of severity and number by increasing flexibility.

Implication for the Air Force: Full -range-of-motion-strength training may promote flexibility. Benefits of flexibility are discussed in the next section.

4.4.10 Cardiovascular Health and Other Illness Prevention

Although the American Heart Association now recommends strength training as part of a balanced fitness program, the effects of strength training on many cardiac-related variables are not definitive. Fleck (1990) summarizes some of these effects, and also indicates that one of the aspect of strength training that has been misunderstood is its effects on cardiovascular fitness.

Although many people believe that increases in resting heart rate and blood pressure are associated with strength training, the scientific literature often shows no effect or slight but significant decreases in both measures. Fleck also considers the increases in peak oxygen consumption engendered by strength training to be much smaller than those associated with running or swimming, for example. Fleck states that decreased total cholesterol, decreased low density lipoprotein, and increased high density lipoprotein are positive adaptations to many cardiovascular training programs, but their association with strength training programs is not clear.

The bulk of research indicates that strength training has limited positive effects on cardiovascular disease (Stone et al., 1991). Some of these positive effects, however small, are these:

- training induced bradycardia (less than 60 beats/min) is considered a benefit of resistance training
- left ventricular volumes of weightlifters are larger than those of non athletes, but smaller than those of endurance athletes
- strength-trained athletes have increased absolute left ventricular mass, increased left ventricular wall thickness, increased septum thickness, and increased septum-to-free-wall ratio
- both stroke volume and cardiac output increase during the eccentric portion of weight training exercise
- body builders had lower blood pressures, both peak and average, compared to controls and novice trainers
- reduced total cholesterol and an improved total cholesterol/HDL-cholesterol ratio have been reported for several weight training groups; these improvements were seen evenly between a weight training group and a jogging group

On the more positive side, work by Paffenbarger (1970, 1975) indicated that longshoremen, whose activities are similar to weight-training tasks, had reduced incidence of cardiovascular disease. In addition, the American Heart Association and the standards of the American Association of Cardiovascular and Pulmonary Rehabilitation (Guidelines for Cardiac Rehabilitation Programs, see Table 1) recommend strength training in their overall fitness plans. Goldberg (1989) and Hurley et al. (1988) suggest that as part of a comprehensive fitness program, strength training may reduce the risk of coronary heart disease. However, they too conclude that cardiovascular and respiratory responses to resistance exercise are similar to those associated with endurance exercise.

Regarding the long-held belief that strength training poses cardiac risk, the Surgeon General's report indicates that it is an exception; exaggerated blood pressure may occur with resistance exercise, due to the involvement of large muscle mass developing considerable force. This force leads to compression of small arteries and increases in total peripheral resistance. Gordon et al. (cited in U. S. Department of Health and Human Services, 1996, p. 65) indicates that the risk is relatively low, but high-intensity resistance training does pose a potential risk to hypertensives. However, hypertensives may benefit from resistance training (Tipton; College of Sports Medicine, both cited in U. S. Department of Health and Human Services, 1996, p. 65).

Strength training has been shown to reduce factors that can be involved in certain kinds of cancer (Koffler et al., 1992) as well as non-insulin dependent diabetes (Miller, Sherman, & Ivy, 1984;

Smutok et al., 1993) Exercise training in general is thought to induce greater insulin sensitivity and rate of glucose disposal. The Surgeon General's report indicates that, "resistance or strength training exercise has also been reported to have beneficial effects on glucose-insulin dynamics in some, but not all, studies involving persons who do not have diabetes" (U. S. Department of Health and Human Services, 1996, p. 128). Several studies support this notion (Stone et al., 1991).

Implications for the Air Force: Strength training may have a positive effect on cardiovascular health.

4.4.11 Confidence, Mood, Self-Image

Duda (1990) believes that the sense of well-being that comes from strength training arises from improved appearance, and consequently leads to self confidence at work and in the social arena. Improved posture also results, which creates a positive impression among fellow workers and others. Fleck (1990) agrees, stating that a benefit of strength training is improved self-image associated with a well-defined body. Livermore (1990) reports strength training participants who find enhanced motivation and heightened spirits. Mood in the elderly was improved with strength training (Milhalko & McAuley, 1996).

A study by Don (1996) reports that both an aerobic group and a strength trained group of college women reported increased in vigor, physical self-concept, self-esteem, physical self-efficacy, and decreased total mood disturbance.

Implication for the Air Force: While strength training improves self-image and mood, there is evidence that aerobic activity provides the same benefit.

4.5 CONCLUSION

Several benefits of strength training have been documented. Of these benefits, some will be of greater value to the Air Force than others. Deployment readiness, safe and efficient everyday work performance, and safer aerobic and team activities will probably be seen as the most important of these issues.

5.0 FLEXIBILITY AND FLEXIBILITY TRAINING

Section 3.0 compared the Air Force Fitness Program with current definitions of fitness, and with recommended fitness programs. Since accepted definitions of fitness include flexibility, and since many organizations promote flexibility training, Section 5.0 will focus on flexibility training and how it might benefit the Air Force.

Can a more flexible work force be of benefit to the Air Force? Several possible benefits will be discussed in this section, but there is a lack of consensus in the scientific literature regarding its value. The following sections define flexibility, discuss the recommendations of subject-matter experts and national health and fitness organizations regarding flexibility training, indicate which military organizations incorporate flexibility training into their fitness programs, and detail some of the literature evaluating possible benefits of flexibility training: (a) as an adjunct to strength training, (b) to ensure safety in work and sports; (c) to decrease the risk of falls, and (d) to decrease problems with lower back pain.

5.1 FLEXIBILITY DEFINED

Flexibility is defined as the range of motion about a joint. Flexibility increases from about age 6 to age 12, when it begins to decline. Women have greater potential for flexibility than men, since their center of gravity is lower and their legs shorter. Although many factors influence a given person's state of flexibility, flexibility can be modified. Movements that emphasize stretching and or strengthening joints will improve flexibility (Greenberg & Pargman, 1986). Stone et al. (1991) caution that flexibility should not be confused with joint laxity, which is hyper joint mobility.

5.2 SUBJECT-MATTER EXPERTS—THEIR VIEWS ON FLEXIBILITY TRAINING

Shephard and Astrand's *Endurance in Sport* (1992) states the benefits of flexibility training as maintenance or improvement of joint mobility, reduction of the risk of joint overloading at extreme joint angles, an increase muscle and tendon strength, enhanced coordination between the various parts of the musculoskeletal system, and adaptation of the musculoskeletal system to the specific demands of a particular sport. Michael Alter's *Science of Flexibility* lists union of the body, mind and spirit; relaxation of stress and tension; muscular relaxation; self-discipline; body fitness, posture, and symmetry; relief of low back pain; relief of muscular cramps; relief of muscle soreness; injury prevention; and enjoyment and pleasure as benefits of a flexibility program. While most texts and sports medicine experts recommend flexibility training, flexibility research is not as comprehensive as that on strength training, and there is little consensus about its benefits. In agreement with this point of view is Nieman (1995), who states:

> Although many sports medicine specialists agree that participation in a regular flexibility program will help a person maintain good joint mobility, increase resistance to muscle injury and soreness, prevent low back and other spinal column problems, improve and maintain good postural alignment, enhance proper and graceful body movement, improve personal appearance and self-image, facilitate the development of motor

> skills throughout life, and reduce neuromuscular tension and stress, there is limited scientific data to support these beliefs. (p. 152)

The belief among many fitness professionals that flexibility training is a valuable component of a fitness program is based on clinical and everyday experiences. Although much of the scientific evidence may appear to be equivocal, it is important to remember that the number and quality of studies performed on flexibility training are not sufficient. As this topic is discussed, the weight of opinion of subject matter experts needs to be considered, as well as the paucity of evidence.

Can a more flexible work force be of benefit to the Air Force? Several possible benefits will be discussed in this section, but there is a lack of consensus in the scientific literature regarding its value. The following sections discuss the recommendations of national health and fitness organizations relative to flexibility training, indicate which military organizations incorporate flexibility training into their fitness programs, and detail some of the literature evaluating possible benefits of flexibility training, (a) as an adjunct to strength training, (b) to ensure safety in work and sports; (c) to decrease the risk of falls, and (d) to decrease problems with lower back pain.

5.3 RECOMMENDATIONS OF NATIONAL PROGRAMS AND PROGRAMS OF MILITARY AND OTHER GOVERNMENT ORGANIZATIONS

A look at Table 1 reveals that flexibility training is recommended by several of the national health and fitness organizations, especially those that are concerned with overall health and fitness as opposed to more specialized populations. The American College of Sports Medicine recommends stretching at least three times a week, with three to five repetitions of each exercise sustained for 10-30 seconds. The Navy, Secret Service, and FBI all have some test of flexibility in their fitness program, as can be seen in Table 2.

5.4 SPECIFIC BENEFITS OF FLEXIBILITY TRAINING

5.4.1 As an Adjunct to Strength Training

When the benefits of strength training are discussed, it should be understood that to the degree that a strength training program is being recommended, some would recommend a flexibility program as well. Does strength training reduce flexibility and should flexibility training be an adjunct for that reason? Being muscle-bound, or inflexible, has long been associated with strength training, and certainly this belief is promoted in many fitness texts, with no reference to scientific literature (see, for example, Shephard & Astrand, p. 341). Whether or not strength training leads to decreased flexibility is not clear. A study by Giruoard and Hurley (1995) compared the flexibility of men trained under a flexibility-only program vs men trained under a strength and flexibility program and found that the combination training produced subjects with less flexibility than the flexibility-only group, as defined by the degree of shoulder abduction, shoulder flexion, and hip flexion ability of this group. The combination group did not differ in flexibility compared to a non-exercise control group. A similar finding is reported by Raab, McAdam, and Smith (1988) in a study of elderly women.

There seems to be greater evidence that resistance training increases flexibility. Wilmore (1978) reported that women increased flexibility 6% and men increased flexibility 8% during a 10-week

resistance-training program. Thrash and Kelly (1987) measured ankle dorsiflexion and shoulder extension after an 11-week, three-times weekly weight training program and found increases in flexibility in the absence of any specific flexibility training. An early study by Massey and Chaudet (1956) indicated that increases in strength were not accompanied by decreases in flexibility.

Most texts and fitness organizations (for example, Allerheiligen, 1994) recommend a flexibility program as a correlate of strength training. Fleck and Kraemer (1997, p. 78) suggest, "Although flexibility training may extend the functional range of motion, control of that range of motion is a function of strength and power development. These two training types appear to be complementary in certain situations." These programs appear to be effective: a study by Wilson, Elliott, and Wood (1992) with male powerlifters found that flexibility training induced a significant reduction in stiffness of the series elastic components of the upper body. Experimental subjects were also able to produce significantly more work during some components of some lifts.

5.4.2 Safer Work and Sports Performance

It has long been held that flexibility protects us from injury during physical work and sports activities. While there may be extensive clinical and anecdotal evidence that this is so, there is no consensus in the literature regarding this relationship. Both sides present empirical evidence to support the advantage or lack of advantage of flexibility training. Interpretations of the data differ widely, with a study by Ekstrand and Gillquist (1983) on injury incidence of soccer players as a function of flexibility being cited as evidence both for (Weaver, Moore, & Howe, 1996) and against (Nieman, 1995) the advantages of flexibility training.

A survey of studies in the workplace examining the relationship between back injury prevention and various interventions (Karas & Conrad, 1996) gives some support to flexibility exercise programs, but caution that, due to the small number of studies and their methodological limitations, conclusions should be viewed conservatively. Also on the side of those who would promote flexibility are Hilyer, Brown, Sirles, and Peoples (1990) who report that flexibility training of municipal firefighters improved their flexibility and reduced the severity (but not the frequency) of injury on-the-job. Stretching is recommended for nurses (Blue, 1996).

The rationale behind stretching and flexibility as a prelude to sports is expressed by Stone et al. (1991). They believe that, when flexible, we move with greater efficiency through a wider range of motion, and that different movements and positions required in sports activities are related to both dynamic and static flexibility.

Stretching is recommended by many as a preliminary to safe sports activity, including tennis (Chandler, 1995) and golf (Kohn, 1996). Stretching and the flexibility those exercises produce have been credited with the reduction of certain types of sports injuries (Beaulieu, 1980; Walker, 1961). A 1983 National Strength and Conditioning Association roundtable discussion (Walthen, 1983) concluded that increased flexibility is beneficial in reducing injuries for players of contact sports, since a blow to an inflexible joint can tear a muscle or connective tissue. Stone et al. (1991) say that the exact relationship between flexibility and injury is not known, but there is empirical evidence that contact and overtraining injuries can be reduced in terms of severity and number by increasing flexibility.

Evidence that training does not reduce injury is a study by Macera et al. (1989) of 583 runners. Those who stretched regularly before running did not have any lower injury rates than runners who did not stretch. Levine, Lonbardo, McNeeley, and Anderson (1987) reported that of 238 athletes in a variety of sports, most did pursue a stretching program, but their practices varied greatly, with some stretching daily, some before the activity, some after, and some both before and after.

Further confusing the issue is a finding by Krivikas and Feinberg (1996) that tight ligaments and muscles are related to injury in male athletes, but not female athletes.

People with very high levels of flexibility, either naturally occurring or obtained through stretching, may be at even greater risk for injury (Cowan et al., 1988). Of 303 male Army recruits, the most flexible recruits (as defined by a toe-touching test) had as many ankle and calf injuries as the least flexible. This U-shape function implies that those who are most flexible have as great a risk for injury as those who are least flexible.

It is difficult to draw a conclusion from these mixed findings. Most fitness texts do recommend stretching as part of a general exercise plan. Everett Harman, in the National Strength and Conditioning Association's *Essentials of Strength Training and Conditioning*, indicates that tight muscles are susceptible to tearing, and since muscles protect cartilage and ligaments, naturally tight people might benefit most from stretching. People who are naturally loose-muscled should only engage in mild stretching. He states that "Stretching is probably most important for athletes engaged in sports that involve extreme ranges of joint motion (e.g., gymnastics). The athlete should be flexible enough to move easily through the range of joint motion required by the sport" (p. 44).

5.4.3 Decreased Risk of Falls

There is some evidence that flexibility training increases coordination, balance, agility, and posture, which contribute to a reduction in the frequency of falls, especially in the elderly (Gehlsen & Whaley, 1990). Again, the assumption is made in this *Review & Analysis* that a better level of fitness when a person leaves the Air Force predicts better fitness in the future. Balance is affected if there is reduced lateral flexion and rotation of the cervical and high thoracic spine that limits the person's ability to use his or her neck (Gladwin, 1996). Reduced hip extension, knee extension, knee flexion, plantar flexion, and dorsiflexion affect walking ability, gait, balance, and posture (Gladwin, 1996). Tinetti et al. (1994) found decreased falls in the elderly as improvements in balance and gait came about through such exercise A program which incorporated the flexibility of Tai Chi administered to a population of the elderly produced favorable effects on the incidence of falls (Wolf, Barnhart, Kutner, McNeely, Coogler, & Xu, 1996). This approach is also recommended by Smith and Gilligan (1991). Ghelsen and Whaley (1990) suggest that an elderly population with a history of fewer falls than another group had better balance, better flexibility, and leg strength. While these benefits might be minimal for the active duty Air Force, paying the medical costs of elderly retirees is a valid consideration.

5.4.4 Reduced Lower Back Pain

Clinical evidence points to lack of flexibility in the lower back/hamstring muscle groups as one of the causes of the majority of cases of lower back pain. A relationship between low back pain and lumbar posteroanterior stiffness was reported by Latimer, Lee, Adams, and Moran (1996).

The American College of Sports Medicine is particularly concerned about the relationship between flexibility in the lower back and posterior thigh region and chronic back pain, and includes that mention in their recommendation for three-times-weekly stretching recommendation. (Weak muscles, as discussed in the previous section, are also implicated.) Fleck (1990, p. 67) also reports that lower back pain is associated with lack of hamstring flexibility. The YMCA's Y's Way to a Healthy Back Program begins with relaxation, then limbering and stretching of the lower back and hamstring areas (Nieman, 1995). However, conflicting evidence is seen in a study (Kirby, Simms, Symington, & Garner, 1981) which showed that gymnasts who had lower back pain had greater toe touching ability than those who were symptom-free.

5.5 CONCLUSION

It is difficult to evaluate these diverse and limited research findings on the benefits of flexibility training. While the benefits of flexibility training for sports and work injury reduction are not clear when the body of scientific evidence is examined, there is almost unanimous agreement among fitness professionals and texts that there are benefits in the sports and health arenas from increased flexibility. In addition, back pain may be reduced as flexibility increases, and there is a documented reduction of falls in the elderly with increased flexibility. Until further research leads to more agreement, the recommendation of the American College of Sports Medicine American College of Sports Medicine (1990) is seen as the best consensus statement available. The organization states that an adequate range of motion is essential for normal musculoskeletal function. The ACSM recommends static stretching three times a week, and that each session involve three to five repetitions of each stretch for 10 to 30 seconds.

6.0 SYNTHESIS

Section 3.1 summarized reasons why the Air Force needs to be fit in general. It was concluded that the Air Force must be fit to perform well under deployment conditions, to conduct daily work efficiently and safely, and to minimize illness and the corresponding medical costs. After this determination of the reasons the Air Force must be a fit force, Section 3.2 defined physical fitness so that it could be determined whether or not the Air Force fitness program matched this definition. It was concluded that the Air Force Fitness Program does not promote the balanced fitness which is mandated by current DoD guidance and which is the hallmark of today's health and fitness standards. Section 3.3 then described the current and historical fitness programs of the Air Force and compared the fitness program of the Air Force against the programs of other relevant Services. It was concluded that the Air Force's program is one-dimensional compared to the programs of other Services.

Sections 4.0 and 5.0 then detailed the benefits of other activities being considered by the Air Force Office for Prevention and Health Services Assessment, that is, strength and flexibility training. (Muscle strength and muscle endurance are highly related on an absolute basis and for military purposes it is possible to combine the concepts of muscular strength and muscle endurance. Both concepts will be assumed with the use of the word "strength" for purposes of this *Review & Analysis*.) It was concluded that adding strength and flexibility training would afford these specific benefits to the Air Force:

1. Troops whose strength training mirrors the kinds of actions that might be required during deployment will be better able to function in emergency conditions. Especially to be considered are personnel who are not required to do physical labor in their everyday jobs, but who may be called upon in time of national emergency to do so.

2. Strength training helps prepare the body for everyday tasks which require physical effort. A strong body will allow the efficient and safe production of a day's work.

3. Strength training programs produce increased strength, increased muscular fitness, increased lean muscle mass, decreased body fat, and increased bone mass.

4. Strength training, probably largely through its effect on muscle mass, can increase rates of resting basal metabolism, which is a benefit in controlling body weight. However, aerobic activity has been shown to produce a similar effect, without a concomitant change in fat-free mass.

5. Strength training can help maintain bone density. This needs to be a special emphasis for the Air Force as more women serve in the military, since they are particularly affected by bone loss. Increased bone mass through strength training could help reduce the rate of fractures of active-duty military, and could decrease the long-term crippling and associated medical costs associated with an aging population seeking military medical care.

6. Strength training produces strong muscles, ligaments, and tendons, which serve as protection against injury during deployment and everyday and sports activities. Especially important for the Air Force's current fitness program is the belief that strong muscles through strength training are essential for the safe performance of aerobic activities.

7. Certain regimens of strength training may increase the aerobic conditioning of Air Force personnel.

8. Strength training could alleviate many common musculoskeletal complaints which require time off from work and costly medical treatment.

9. Full-range-of-motion-strength training may promote flexibility.

10. Strength training may have a positive effect on cardiovascular health.

11. While strength training improves self-image and mood, there is evidence that aerobic activity provides the same benefit.

12. Flexibility training may promote safer sports activity, although data are inconclusive.

13. Flexibility training may lower the incidence of lower back pain.

14. Flexibility training may reduce injury due to falls in the retired Air Force population.

Of the benefits of strength training, some certainly have a greater potential impact than others. While many of the benefits indicated above are attainable through other fitness activities such as aerobics, some are unique to strength training. The most important benefits to the Air Force are seen to be deployment preparedness, more efficient and safe everyday work performance, and improved safety during aerobic and team sports. Injuries should be reduced during these activities if strength training were promoted by the Air Force Fitness Program. Since the current Air Force Fitness Program promotes aerobic activity, strength training as an adjunct would be a certain benefit. Another very important benefit of strength training is the probable increase in bone mass and the anti-osteoporosis impact of weight-bearing strength training. Fewer fractures in the current and retired Air Force populations would save absenteeism costs and medical treatment costs.

Whether or not the remaining benefits are attainable through aerobic activity, implementing a strength training program will certainly add to the level of general fitness of Air Force personnel. A more fit force will be better able to perform under deployment conditions, will perform everyday jobs more efficiently and safely, will be absent from work less often, and will require less medical treatment.

The benefits of flexibility training are less clear. While flexibility training seems to be a universal prescription in fitness and health texts, the scientific data do not universally support the purported benefits of flexibility training for work or sports injury reduction, but experimentation has not been thorough enough to reach a positive or negative conclusion. There is a great deal of agreement among fitness professionals that flexibility and stretching exercises are of benefit, and in addition, there is a documented benefit in terms of decreased probability of falling for more flexible people. Improvements in flexibility may lead to a lower incidence of back pain. For these reasons, and on the basis of recommendations of other fitness programs, it is suggested that the Air Force add flexibility training to its programs.

7.0 RECOMMENDATIONS

7.1 SUMMARY OF RECOMMENDATIONS

These are the conclusions reached after an analysis of the popular and scientific literature, and the comparison of these findings with the current Air Force program.

1. The Air Force would receive specific health and fitness benefits by adding strength training to its fitness program; these benefits need to be weighed against the costs of establishing and implementing a reliable and valid test program.
2. Given that many fitness programs recommend flexibility training despite the lack of consensus among research findings, and because it provides some protection against lower back pain and falling, the Air Force should implement a program which includes flexibility training, at least until further research reaches agreement otherwise.

7.2 POSSIBLE DRAWBACKS TO RECOMMENDATIONS

7.2.1 Rate of Injury

It was originally thought that adding a strength training emphasis to the Air Force's fitness program would add to rate of injury. A study of the literature on the epidemiology of sports injuries does not support this contention. Although studies of the causes of sports injury are fraught with definitional and experimental design problems (see Caine, Caine, & Lindner, 1996 for a thorough explanation of these factors), a comprehensive study by Garrick and Requa (1996) took into account several of these concerns and allows us to draw reasonable conclusions. The study was based on the activity rates of adult fitness participants, who volunteered their time and effort for this study. Respondents were required to already be performing a certain number of fitness activities per week, and they agreed to be interviewed on a regular basis for the twelve weeks of the study. Starting with a sample of over one thousand recreational athletes, over 10,000 hours of athletic activity were documented. Rates of injury that occurred for each type of activity are documented in Table 3, *Rate of Injury/1000 Hours of Activity*. The rates for categories with more than 250 hours of activity were highest for team sports such as basketball, were at an intermediate level for running and aerobic dance, and were lowest for exercise cycling, walking, and weights and weight machines. Fleck and Kraemer (1997) state that the chance of being injured while performing resistance training is very slight. Zemper (1990) cites a very low (0.35 per 100 players per season) injury rate attributed to weight training among college football players. Weight-room injuries accounted for only 0.74% of time-loss due to injuries during the football season. Zemper also notes that an injury rate such as this could be even lower through rigorous attention to proper procedures during weight training.

Given that the rate of injury that might occur due to strength training activities is not very high, and due to the evidence presented above, that muscle strength has a preventive effect regarding possible injuries incurred during aerobic activity, it appears that adding strength training to the Air Force fitness recommendations will not adversely affect injury rates during physical activity.

Table 3. Rate of Injury/1000 Hours of Activity

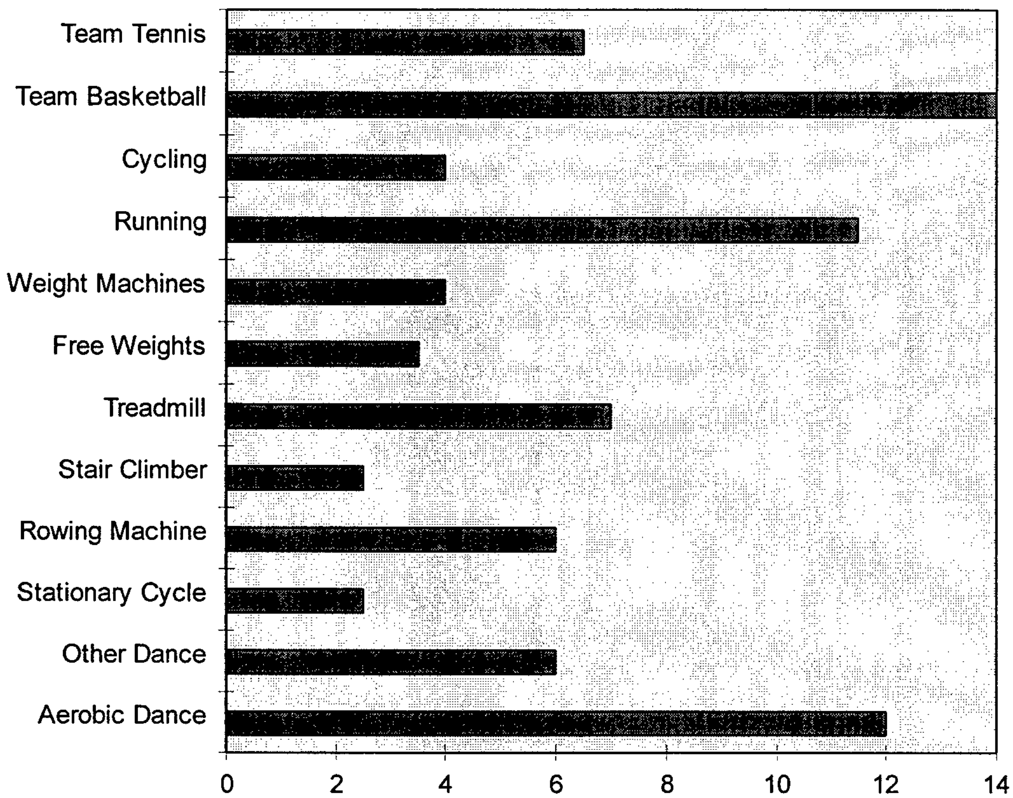

Table adapted from Garrick and Requa (1996)

7.2.2 A Change in Policy

A second potential cost to the Air Force is that any change in procedure will be disruptive and will require significant effort on the part of the AFFP to specifically determine and enact a change. Establishing new procedures and ensuring compliance will be two major considerations. The greatest practical issue, if components are going to be added to the Air Force Fitness Program, is the design of the new program. Although some suggestions are made in this *Review & Analysis* regarding selection of measures to be used for strength and flexibility assessment, these ideas are preliminary. Any measures chosen must be backed by scientific studies that document their reliability and validity. The Air Force must employ tests that minimize subjectivity, that is, a sit-up that is deemed sufficient by one rater must judged sufficient by that same rater on a different day, and must be judged sufficient by a second rater on either of those testing occasions as well. A valid test is one that measures the characteristic it purports to measure.

While work has been done on reliability and validity of test measures, the more difficult task is to determine standards, or metrics, which must be met for a person to pass each test. Norms have been documented for many populations and many fitness tasks, but adapting these in some rational manner for military use is a complex issue. Since the career implications of passing the fitness test are important, establishing fair and credible standards is crucial. How can these values be best established? If we know the mean value of a civilian adult population for number of sit-ups in two minutes, how can we use this to establish a military standard, given that half of the civilian population produced fewer sit-ups? Should this mean be incremented by a third for a military population? Decreased by a half? Should standards vary by age? Sex? Job category? On what basis can these decisions be made? Perhaps the complexity of establishing such norms can be approximated by reviewing one of the several volumes published in conjunction with the multi-year, multi-stage Canadian Armed Forces effort to determine a minimal physical fitness standard based on common military tasks (Stevenson et al., 1988).

7.2.3 Cost of Administration

On the part of the test administrators, any change in the Air Force Fitness Program will incur a cost, at least in the time in takes to establish and train for new testing procedures. However, the policy which has placed a fitness professional in each of the HAWCS, the Health and Wellness Centers at many Air Force bases, should make any change easier to put into place.
While muscle strength and endurance can be assessed with the use of machines, the other Services' low-cost solution has been to evaluate muscle fitness with resistance exercises, such as chin-ups and sit-ups. The time to test could be minimal, with partners timing and counting for one another. The other Services test large groups at one time with no equipment.

7.3 IMPLEMENTATION OF RECOMMENDATIONS

How can the Air Force Fitness Program Office best promote strength and flexibility training? Clearly, testing alone for these variables is not sufficient. How can the Air Force Fitness Program Office best encourage training programs for Air Force personnel? What tests will best determine compliance with a suggested training program?

7.3.1 A Training Program

It is recommended that the Air Force encompass strength and flexibility training into their Air Force Fitness Program. It is not sufficient or healthy to have a testing requirement only, so it is recommended that the Air Force promote strength and flexibility training on a regular basis.

How can people be encouraged to exercise? Table 4, *Summary of Variables that May Determine the Probability of Exercise*, from Dishman, Sallis, and Orenstein (1985), indicates some of the factors that have been shown to affect the probability that a person will engage in a supervised or spontaneous exercise program. While no clear pattern is seen, there is some indication that health issues have an impact on exercise probability. For instance, those with high risk for coronary heart disease, those who are aware of their health status, and those who expect that exercise will producer some health benefit were motivated to exercise. This suggests an avenue for the Air Force, that is, promoting physical activity as a way to stay healthy.

A summary of the literature of interventions designed to promote physical activity is not encouraging. Table 5, *Studies of Interventions to Increase Physical Activity among Adults*, summarizes various interventions (such as self-monitoring, health information communication, behavioral management, team building) and their outcomes. The studies themselves have not been rigorously designed or administered, so it is difficult to draw meaningful conclusions. The positive results seen in controlled interventions in the workplace do show some small improvement in exercise frequency, in the range of 5-10 %, and it is often short-lived.

When volunteers in a NASA exercise program were asked why their attendance was not regular, they indicated that workload, travel, conflicts between job and the exercise program schedule, and physical problems kept them for working out (Durbeck et al., 1973). Since these issues are a constant in everyone's life, some outside motivation needs to accompany any military fitness program.

Does a mandatory level of fitness need to be backed by a mandatory fitness training program? The Air Force, of all the US military Services, does not have an official policy which allows duty time for physical fitness, although some commanders do mandate these hours. A change in this policy would be a great motivator for personnel to engage in fitness activities. It would indicate how seriously the Air Force regards physical fitness.

In any event, a time-efficient solution would be to integrate strength and flexibility activities into an aerobic conditioning program. For bases with such facilities, incorporating a circuit training program would be an ideal and efficient way for personnel to accomplish aerobic and muscle conditioning in a short period of time. Circuit training requires that a person proceed through a series of weight stations (free weights, isotonic, and isokinetic machines) at a rapid pace. Gains include aerobic conditioning as well as muscular strength and endurance gains. Vogel (1985) indicates that resistance for a circuit training program can be relatively low (50-60% of one rep's maximum), with 12-20 repetitions, and 10-20 sec rests between stations.

Alternatively, calisthenics such as sit-ups and push-ups are an option for strength training. Calisthenics are often recommended to promote muscle strength and muscle endurance (Nieman, 1995; Boff, 1975), although other forms of activity might provide better results. Marcinik (1984) contrasted circuit weight training programs with aerobic-calisthenic programs on Navy

Table 4. Summary of Variables that May Determine the Probability of Exercise

Determinant	Changes in Probability Supervised Program	Changes in Probability Spontaneous Program
Personal Characteristics		
Past program participation	++	
Past activity outside of programs	+	
School athletics, 1 sport	+	0
School athletics, >1 sport		+
Blue-collar occupation	--	-
Smoking	--	
Overweight	--	
High risk for coronary heart disease	++	
Type A behavior	-	
Health and exercise knowledge	-	0
Attitudes	0	+
Enjoyment of activity	+	
Perceived health	++	
Mood disturbance	--	--
Education	+	++
Age	00	-
Expected personal health benefit	+	
Self-efficacy for exercise		+
Intention to adhere	0	0
Perceived physical competence	00	
Self-motivation	++	0
Evaluating costs and benefits	+	
Behavioral skills	++	
Environmental Characteristics		
Spouse support	++	+
Perceived available time	++	+
Access to facilities	++	0
Disruptions in routine	--	
Social reinforcement (staff, exercise partner)	+	
Family influences		++
Peer influence		++
Physical influences		+
Cost		0
Medical screening	-	
Climate	-	
Incentives	+	
Activity Characteristics		
Activity intensity	00	-
Perceived discomfort	--	-

Key: ++ repeatedly documented increased probability; + weak or mixed documentation of increased probability
00 repeatedly documented that there is no change probability; 0 weak or mixed documentation of no change in probability
-- repeatedly documented decreased probability; - weak or mixed documentation of decreased probability
blank spaces indicate no data

Source: Dishman, R., Sallis, J., Orenstein, D. (1985). The determinants of physical activity and exercise. Public Health Reports 100: 156-157. In D.C. Nieman (1990). Fitness and sports medicine. An introduction. Palo Alto, CA: Bull.

Table 5. Studies of Interventions to Increase Physical Activity Among Adults

Study	Design	Theoretical approach	Population	Intervention	Findings and comments
Individual approaches					
Weber and Wertheim (1989)	3 month experimental	Self-monitoring	55 women who joined a gym; mean age = 27	I-1: Self-monitoring of attendance, fitness exam I-2: Self-monitoring, staff attentions fitness exam C: Fitness exam	I-1 had better attendance than I-2 overall; interest -in self-monitoring waned after 4 weeks
King, Haskell, et al. (1995)	2 year experimental	Behavioral management	269 white adults aged 50-65 years	I-1: Self-monitoring, telephone contact, vigorous exercise at home I-2: Self-monitoring, telephone contact, moderate exercise at home I-3: Self-monitoring, vigorous exercise in group	Better exercise adherence at 1 year in home-based groups; at year 2 better adherence in vigorous home-based group; 5 times per week schedule may have been difficult to follow
Lombard, Lombard, Winett (1995)	24 week experimental	Stages of change	155 university faculty and staff; mostly women	I-1: Weekly calls, general inquiry I-2: Weekly calls, structured inquiry I-3: Call every 3 weeks, general inquiry I-4: Call every 3 weeks, structured inquiry	Frequent call conditions had 63% walking compared with 26% and 22% in the infrequent condition; frequent call and structured inqu had higher rate of walking than other groups
Cardinal & Sachs (1995)	12 week experimental	Stages of change	113 clerical staff at a university; mean age = 37; 63% black	I-1: Mail-delivered lifestyle packet based on stages of change I-2: Mail-delivered structured exercise packet with exercise prescription C: Mail-delivered fitness feedback packet	No difference in stage of change status among or within groups
Belisle (1987)	10 week quasi-experimental with 3-month follow-up	Relapse prevention	350 people enrolled in, beginning exercise groups	I: Exercise class and relapse prevention training C: Exercise class results across experimental groups	Higher attendance in relapse prevention group over 10 weeks and at 3 months; high attrition and inconsistent
Gossard et al. (1986)	12 week experimental	Behavioral management	64 overweight healthy men aged 40-60 years	I-1: Vigorous self-directed exercise, staff telephone calls, self-monitoring I-2: Moderate self-directed exercise, staff telephone calls, self-monitoring C: Staff telephone calls	Better adherence in the moderate-intensity group at 12 weeks compared with vigorous (96% vs. 90%) (no statistical tests reported); travel, work schedule conflicts, and weather were note to physical activity
King, Carl, et al. (1988)	16 week pretest-posttest	Behavioral management	38 blue-collar university employees; mean age = 45	I: 90-minute classes 2 times/week after, work, parcourse, self-monitoring, contests C: None	Twofold increase in bouts of exercise compared with nonparticipants. Participants different from nonparticipants at baseline
King & Frederiksen (1984)	3 month experimental	Relapse prevention, social support, behavioral management	58 college women aged 18-20 years	I-1: Team building, relapse prevention training; group exercise I-2: Team building, group exercise I-3: Relapse prevention training and jogging alone C: Jogging alone	I-2 and I-3 had twice the jogging episodes as I-1 and C at 5 weeks; at 3 months, 83% of I-3 were jogging compared with 38% of I-1 I-2 and 36% of C
King, Taylor, et al. (1988)	Study 1: 6 month experimental	Relapse prevention, behavioral management	152 Lockheed employees aged 42-55 years	I-1: Home-based moderate exercise, self-monitoring with portable monitor, relapse prevention training, telephone calls from staff I-2: Same as I-1 without telephone calls from staff	No difference in number of sessions and duration reported at 6-month follow-up
	Study 2: 6 month experimental	Behavioral management	Lockheed employees from Study 1	I-1: Daily self-monitoring I-2: Weekly self-monitoring	I-1 had more exercise bouts per month (11 vs. 7.5)
Marcus and Stanton (1993)	18 week experimental	Relapse prevention	120 female university	I-1: Relapse prevention training and exercise	Better attendance in I-1 at 9 weeks; no difference at

		social learning theory	employees, mean age = 35	I-2: Scheduled reinforcement for attendance and exercise C: Exercise only	18 weeks or 2-month follow-up
McAuley et al. (1994)	5 month experimental	Social learning theory	114 sedentary middle-aged adults	I: Modeling of exercise, provision of efficacy-based information (mastery accomplishments, social modeling, social persuasion, physiological response), walking program C: Biweekly meetings on health information, walking program	Better class attendance (67% vs. 55%) and more minutes and miles walked among intervention group than controls
Owen et al. (1987)	12 week quasi-experimental	Behavioral management	343 white-collar and professional workers, mean age = 36, mostly women	I: Self-management instruction, exercise class C: Exercise crass	No difference in activity levels at 6 months
Robison et al. (1992)	6 month quasi-experimental	Behavioral management, social support	137 university staff at 6 campus worksites, mean age = 40	I: Weekly group meetings, contracts, cash incentives, social support, exercise C: Exercise, diary	Higher attendance among experimental groups than comparison groups (93-99% vs. 19%)
Community approaches					
Luepker et al. (1994) (Minnesota Heart Health Project)	5 to 6 year quasi-experimental; (3 matched pairs)	Diffusion of innovations, social learning theory, community organization, communication theory	Community longitudinal cohort (n = 7,097), Independent survey (n = 300-500)	I: Screening and education; mass media; community participation; environmental change; professional education; youth and adults C: Nothing	Percent physically active higher in independent survey at 3 years; higher in the cohort at 7 years
Young et al. (in press) (Stanford Five-City Project)	7 year quasi-experimental	Social learning theory, communication theory community organization	2 sets of paired, medium-sized cities (5th city used for surveillance only)	I: Print materials; workshops and seminars; organized walking; organized walking events; "Heart & Sole" groups; worksite programs; TV spots	Men increased participation in vigorous activities; men and women in the intervention communities increased their overall number of physical activities; significant differences between intervention and comparison communities at baseline
Macera et al. (1995)	4 year quasi-experimental (2 matched communities)	None specified	Community residents ≥ 18 years; 24% African American (I), 35% African American (C)	I: Community cardiovascular risk reduction activities C: None specified	No difference in physical activity prevalence, physician counseling for exercise, or exercise knowledge
Brownson et al. (1996)	4 year quasi-experimental	Social learning theory, stage theory of innovation	Rural communities; largely African American	I: Community organization; development of 6 coalitions; exercise classes and walking classes and walking clubs; demonstrations; sermons; newspaper articles; community improvements; $5,000 to each coalition from the state health deportment	Increased physical activity levels in coalition communities, declining levels in communities without; net effect was 7%. Plan Approach to Community Health education planning model
Marcus, Banspach, et al. (1992) (Pawtucket Heart Health Program: Imagine Action)	6 week pretest-posttest uncontrolled	Stages of change	610 sample of community residents, mean age = 42	Written materials, resource manual, weekly fun walks, and activity nights	Participants more active after intervention with movement toward action and low relapse to earner stage; suggests stage-based community intervention can result in movement toward action; study uncontrolled
Worksites					
Blair et al. (1986) (Live for Life)	2 year quasi-experimental	None	4,300 Johnson & Johnson employees	I: Screening, lifestyle seminar; exercise programs; newsletters; contests; health communications; no smoking policies C: Screening only	20% of women and 30% of men began vigorous exercise of 2 years
Fries et al. (1993)	24 month experimental	None	4,712 Bank of America retirees	I-1: Health risk appraisal; feedback letter; behavioral management materials; personalized health promotion program I-2: Health risk appraisal; no feedback; full program in year 2 C: No Intervention	No difference in physical activity year 1 ; I-1 greater physical activity in year 2 over I-2
Heirich et al. (1993)	3 year experimental	None specified	1,300 automobile plant workers	I-1: Fitness facility I-2: Outreach and counseling to high risk employees I-3: Outreach and counseling to all employees C: Health education events	Percent exercising 3 times per week: I-1 = 30%, I-2 = 44%, I-3 = 45%, C = 37%

Communication

Osier and Jespersen (1993)	2 year quasi-experimental	Social learning theory, communications (diffusion of innovations); community organization	Rural communities in Denmark (n = 8,000 [I])	I: Heart Week with assessments, health education, weekly community exercise TV, radio, newspaper community messages C: Not specified	No difference in self-reported physical activity, but intervention community expressed more interest in becoming active; low response rate to surveys (59%); became mainly a media campaign with little community involvement
Owen et al. (1995)	2 year pretest-posttest	Social learning theory, social marketing theory	2 national physical activity campaigns in Australia	I: Messages to promote walking and readiness to become active; modeling activity; radio and TV PSAs; T-shirts; special scripting of soap operas	1st campaign--increase in percent who walked for exercise (70% to 74%), greatest impact on 50+ age group (twofold increase in reported walking not significant) 2nd campaign-small declines in reported walking and in intentions to be more active
Brownell, Stunkard, Albaum (1980)	Study 1: 8 week quasi-experimental	None specified	21,091 general public observations at a mall, train station, bus terminal	I: Sign reading "Your heart needs exercise-- here's your chance"	Number of people using the stairs increased from 5% to 14% when sign was up. Use declined to 7% when, sign was removed
	Study 2: 4 month quasi-experimental	None specified	24,603 general public observations at a train station	I: Sign reading "Your heart needs exercise- here's your chance"	Number of people using the stairs increased from 12% to 18%; effect remained for 1 month after sign was removed
Blamey, Mutrie, Aitchison (1995)	16 week quasi-experimental	None	22,275 subway users observations	I: Sign reading "Stay Healthy, Save Time, Use the Stairs"	Baseline stair use increased to 15-17% when sign was up; persisted at 12 weeks after sign removal; larger increase among men

Key:
I = intervention; C = control or comparison group.

Adapted from:
U. S. Department of Health and Human Services. (1996). *Physical activity and health: A report of the surgeon general.* Atlanta, GA: U. S. Department of Health and Human Services.

men and women and found that greater strength and endurance were achieved with the circuit training. Vogel (1985) also states that calisthenic programs are not as effective in enhancing muscular strength. Individualized progressive weight resistance is necessary for efficient strength training. While weight machines are not essential, weighted boxes or objects or some form of resistance can be used.

7.3.2 Suggested Test Program Additions

Fitness testing has grown into a discipline all its own. Hundreds of texts report extensive research and reviews of the field. The American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD) has published extensively under this topic. Good guidelines are found as well in the American College of Sports Medicine's *Resource Manual for Guidelines for Exercise Testing and Prescription* (1993). This section reports information about different test batteries and makes some suggestions for additions to the Air Force Fitness Program.

In order to determine appropriate measures of muscle strength, muscle endurance, and flexibility to incorporate into the AFFP, it is necessary to resolve why it is that the Air Force must be fit. What tasks ought all military personnel be strong enough to accomplish? If we consider basic military tasks as suggested earlier by the Canadian Forces, then troops must be able to operate a weapon, perform first aid and evacuation, execute survival and rescue operations, and perform general security duties. Consider as well that medical personnel who deploy must carry about a hundred pounds of gear on and off their aircraft, and must be able to carry tent components, erect tents, and carry patients on gurneys. And of course, anyone going TDY should be able to haul a suitcase, briefcase, and laptop through the airport. What components of fitness are represented by these tasks? It appears that tasks which might be required in the line of Air Force duty would probably require both muscle strength, muscle endurance, and aerobic fitness. On that assumption, the activities suggested below were chosen as a basis for strength and muscle endurance training as well as their evaluation (Knapik, 1989 states that muscular strength and absolute muscular endurance are highly correlated, justifying the Army's use of a single measurement for both).

The specifics of this question deserve further attention from Air Force fitness planners. An analysis of tasks that would be required by different Air Force units under deployment in the context of everyday work could be used to form a valid training and test program.

Two fitness batteries are suggested here for consideration by the Air Force. The goals of their developers were similar, to produce valid and reliable measures of fitness which could be used to evaluate large populations of adults. Although both batteries address a wide range of tests and fitness factors (e.g., body composition), the discussion here will be limited to flexibility, muscle strength and muscle endurance.

7.3.2.1 The Eurofit Test Battery for Adults

The Eurofit Test Battery for Adults arose from concern expressed in the 1989 Conference of European Ministers Responsible for Sport, held in Reykjavik, over increasing numbers of less-fit individuals. The Committee for the Development of Sport (CDDS) prepared this test battery to be used for an adult population, although another version exists for assessment of children. Oja and Tuxworth (1995) state that this battery is not final or perfect and that, to produce a fitness battery that will be practical, valid, and reliable, more experience and research will be necessary.

They consider the Eurofit a working tool, which although imperfect, still will promote physical activity.

The authors state that the proposed tests all "represent approved, valid, and reliable measures" (p. 37) of the components in question. For muscle strength and muscle endurance testing, the dynamic sit-up (knees bent, held by experimenter, sit-ups to front and then diagonally) is used. The vertical jump is used to assess leg muscle power, and the bent-arm hang measures arm muscle endurance. Hand muscle strength is evaluated with a hand grip. Side-bending or sit-and-reach tests measure trunk flexion.

7.3.2.2 A Test Battery by Suni et al.

A second test battery is recommended by Suni et al. (1996). In addition to other variables, the Suni et al. battery tests for flexibility, muscle endurance (upper body) and muscle strength (lower body). Two studies were conducted to assess inter-rater reliability for field assessment of health-related fitness, making this an important study for the Air Force, since the subjectivity of testers is an issue in mass testing, especially when careers can be affected. The authors state that:

> When fitness testing is used as a tool to promote health-related exercise in large populations, the methods need to be simple, practical, and safe under conditions available in ordinary communities. In addition, the methods must be reliable to obtain valid and useful information about the fitness levels of individuals or populations. (p. 399)

The selection of measures to be tested was based on a literature review of fitness assessment methods in the context of reliability and health-related validity. The studies involved 499 male and female subjects whose ages ranged from 25 to 59 years. To determine inter-rater reliability, intraclass correlation coefficient of repeated measures was used. Trial-to-trial variability and day-to-day variability were also assessed.

The authors concluded that, of the several measures studied, the following tests had acceptable reliability for field testing:

- Side-bending is used to assess **spinal flexibility,** specifically the lateral flexion of the thoracic and lumbar spine and pelvis. The movement is a bend to the right and left as far as possible keeping shoulders and buttocks in contact with a wall. Feet are 15 cm apart and arms are kept straight at the sides. The change in position of the tip of the middle finger is the measure (vertical displacement down the thigh).

- To assess **upper-body muscular function, modified push-ups,** with the touch of one hand on the top of the supporting hand to standardize the "up" position. Push-ups are of the straight-leg variety, and as many as possible are produced within 40 seconds.

- **Leg extensor power was assessed by the jump and reach test**, with the subject jumping as high as possible. Subjects made a mark on the jump-and-reach board overhead, as they jumped. Subjects could flex their knees in preparation, but not move their feet. The **one-leg squat test** assessed the **lower extremity extensor strength.** Squats started at body weight and then 10% of body weight was added in increments to a weight belt until the subjects felt they could not step with any more weight.

The authors stress that in addition to a reliable assessment tool, it is vital to provide training for testers to ensure reliable and useful testing.

7.3.3 Other Test Recommendations

In addition to the suggestions of Suni et al. and Eurofit, the tests that follow represent exercises included in physical fitness batteries frequently used by subject matter experts and employed by national organizations, as specific tests for strength and muscle endurance. Specific exercises were extracted based on their prevalence of use and prescription to measure either muscular strength and endurance or flexibility. The selected tests represent measures "that are economical in terms of time, money, and ease of administration, and are effectively health-related" (Nieman, 1990, p. 152).

7.3.3.1 Tests for Muscular Strength and Muscular Endurance

No single test can be used to measure total body muscle strength and endurance, as it is specific to each muscle group. It is thus recommended that multiple measures be taken; these should include muscle groups from the upper, mid, and lower body to obtain accurate measures of muscle strength (Greenberg and Pargman, 1986).

Sit-ups are a widely used test to measure abdominal muscle strength and endurance. Of the batteries reviewed, sit-ups were used in several of the texts, and by national organizations including the YMCA Test Battery, the Canadian Standardized Test of Fitness (CSTF), and the American Association of Health, Physical Education, Recreation and Dance (AAHPERD). The test requires an individual lying on his or her back with knees bent to raise the upper body toward the knees. Nieman (1990) speaks to the controversy and dissatisfaction surrounding the sit-up despite its widespread application. Specifically, the problem lies in the use of the hip flexor muscles during the sit-up which results in increased stress on the lower back. Nonetheless, the sit-up is still used and scores are obtained from the number correctly completed in a specified time limit. The scores are converted based on rating scales; generally the ratings are gender-dependent and some are also age-based.

A test which measures the strength and endurance of the upper body is push-ups. National programs such as the Canadian Standardized Test of Fitness (CSTF) and *FITNESS*GRAM incorporate them into their batteries. Push-ups involve lying facing the floor and raising the body off of the ground, using the arms, with only toes and hands touching the ground. This movement incorporates coordination of the triceps, anterior deltoids, and pectoralis major muscle groups (Nieman, 1995). Most batteries reviewed prescribe use of the bent-knee posture for females, and a limited number also advocated this version for males. As with sit-ups, a score

is obtained based on the number correctly performed in a specified time, usually a minute or two. The score is then converted to a rating based on gender and generally age.

The pull-up is another test of muscular strength and endurance of the upper body, specifically the arms and shoulder girdle (Cooper, 1997). The exercise is performed by hanging underhand from a bar and pulling one's body up so that the chin is above the bar. Its use is advocated by proponents of the *FITNESS*GRAM program. As with push-ups, a modified version called the flexed-arm hang, is often administered to females. The score and ranking for pull-ups is evaluated in the same manner as both the sit-ups and push-ups.

Finally, the bench press is often used to measure muscular strength and endurance of muscle groups involved in extension of the arms. Two distinct forms of the bench press test are available. The first is the one-repetition maximum test which is predictive of total dynamic strength (Nieman, 1995). The test involves lifting weights until the maximum weight that can only be raised once is reached. This score is then divided by the person's weight to obtain a ratio which is rated based on gender. The other form is used in the YMCA test battery and tests for endurance. Absolute weights, 35-pounds for women and 80-pounds for men, are lifted at a rate of 30 lifts per minute. The score is the number of completed repetitions and is rated based on age. This test is good for occupations with handling requirements of absolute weight, but discriminatory against persons of lighter weight (Nieman, 1990).

7.3.3.2 Tests for Flexibility

No measure exists to quantify total body flexibility. Instead, the flexibility of particular joints are tested (Getchell, 1987). The flexibility measures taken should not be over-generalized; "flexibility of a certain joint does not necessarily indicate flexibility in other joints" (Nieman, 1990, p. 150).

"Nearly all health-related physical fitness testing batteries now use the sit-and-reach test for a measure of flexibility" (Nieman, 1990, p. 150). The sit-and-reach is a test wherein an individual sits with legs extended in front of them and extends their upper torso and arms in the direction of their feet as far forward as possible. Scores are not affected by varying leg lengths, arm lengths, or their ratios. Of the batteries reviewed, the sit-and-reach was used in several of the texts, and by national organizations including the YMCA Test Battery, the Canadian Standardized Test of Fitness (CSTF), the American Association of Health, Physical Education, Recreation and Dance (AAHPERD), and FITNESSGRAM. The sit-and-reach test measures the flexibility of the lower back and posterior leg muscles, and is used largely because of the prevalence of lower back problems in the US (Nieman, 1995). Nieman (1995) lists the following as norms for the sit-and-reach test:

Classification	Sit-and-Reach (inches)
Excellent	≥+7
Good	+4-6.75
Average	+0-3.75
Fair	-3-0.25
Poor	<-3

Note that the above ratings are not age or gender dependent. Some batteries do state norms based on gender and age with a general pattern of flexibility declining with age and females having overall greater flexibility than males.

Other methods used to assess flexibility include the shoulder reach test and the trunk extension test. The shoulder reach measures the flexibility of the shoulder muscles. It is an exercise that requires the person to raise one arm up and then reach down the back in an attempt to meet the other arm reaching up and behind the back. The trunk extension test measures the flexibility of the back. For this exercise, an individual lies on his or her stomach and attempts to raise the upper body off of the floor.

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